CANADA

COMPENDIUM OF ARMS CONTROL VERIFICATION PROPOSALS

Third Edition

VOLUME
2

Chapters D - J

MAY 1987

External Affairs Canada

Affaires extérieures Canada

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TABLE OF CONTENTS

	PAGE	VOLUME

CHAPTER D

IAEA SAFEGUARDS

Abstracts dealing with International Atomic Energy Agency (IAEA) safeguards have been located in a separate chapter for three reasons. First, although selective on-site inspection is perhaps the predominant verification method in the safeguards system applied by the IAEA, the system depends for its effectiveness as well on a combination of other techniques including records monitoring (plant), short-range sensors (seals and monitoring devices), international exchange of information (reports to an international body), national self-supervision (i.e. a national nuclear materials accounting system) and an international control organization. While IAEA safeguards are not a generic verification type *per se*, they do comprise a unique, functioning verification system employing a number of verification techniques.

Second, the IAEA safeguards system has been used as a model for proposed international control systems for arms control agreements other than the Nuclear Non-Proliferation Treaty for which the system has primarily been designed. For example, some verification proposals have suggested that a safeguards-like system could be used to monitor a chemical weapons convention. The safeguards system is viewed by many as a precedent for application to other arms control verification problems.

Third, since there are a large number of proposals in this edition of the *Compendium*, which deal with the safeguards system as a whole, they have been grouped together for easy access.

The IAEA safeguards system is designed to verify the non-proliferation of nuclear weapons. It constitutes the primary verification mechanism of the multilateral Non-Proliferation Treaty (D9(T68)). Two key documents define the safeguards system and outline the relationship between the IAEA and various states (see abstracts D10(I68) and D12(I72)). A series of five booklets published by the IAEA outlines the safeguards system in considerable detail (see abstracts D26(I80), D35(I81), D46(I83), D52(I84), D56(I85)). One notable development in safeguards technology with potential widespread application is an experimental system called RECOVER (Remote Continuous Verification) which is designed to verify that short-range sensors (containment and surveillance equipment including cameras) are functioning properly. RECOVER transmits information on the status of the equipment to a central monitoring authority. Originally intended to supplement the IAEA safeguards system (see, for example, abstract D45(G83)), RECOVER has also been suggested for application in verification of a chemical weapons convention (see, for example, abstract I20(G85)). Abstracts dealing with the RECOVER system are located in several chapters and can be found in the subject index under the heading "SHORT RANGE SENSORS - MONITORING DEVICES - RECOVER".

As mentioned above, safeguards-like systems have been proposed in combination with other methods to monitor arms control agreements other than those dealing with nuclear non-proliferation. These include a comprehensive test ban, a fissionable material "cutoff" and a chemical weapons convention. When safeguards are not the principal verification method in a proposal, the proposal abstracts may appear in other chapters of this volume. However, all proposals dealing with IAEA safeguards can be located using the Subject Index under the heading "ON-SITE INSPECTION - IAEA SAFEGUARDS".

Proposal Abstract D1(T67)

1. **Arms Control Problem:**
   (a) Regional arms control - nuclear weapons free zones
   - Latin America

   (b) Nuclear weapons - proliferation
   - peaceful nuclear explosions

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards (Article 12)
   (b) Complaints procedure - referral to new international body (OPANAL, Article 16)
   - referral to Security Council
   - referral to General Assembly
   - referral to Organization of American States

   (c) International control organization

3. **Source:**
   Treaty for the Prohibition of Nuclear Weapons in Latin America. (The Treaty of Tlatelolco).
   Concluded: 14 Februrary 1967*
   Number of parties as of 31 March 1984:
   - to Treaty: 25
   - to Protocol I: 4
   - to Protocol II: 5

4. **Summary:**
   This Treaty seeks to prevent the spread of nuclear weapons in Latin America. The scope of the verification system is defined in Article 12(2) and includes verifying:
   (1) that peaceful nuclear service and equipment are not used to test weapons,
   (2) that no activity prohibited under the Treaty (Article 1) occurs using nuclear weapons from outside the zone, and
   (3) that PNEs are conducted according to Article 18.

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* The Treaty enters into force for each state that has ratified it when the requirements specified in the Treaty have been met (i.e. when all states in the region when the Treaty was opened for signature ratify it, when nuclear weapons states have ratified Protocols 1 and 2; and when safeguards agreements are concluded with the IAEA), unless the party ratifying the Treaty issues a waiver of these conditions.

To achieve these ends the Treaty calls for the application of IAEA safeguards to each party's nuclear activities (Article 13). Under Article 14, parties are required to submit semi-annual reports to the Agency for the Prohibition of Nuclear Weapons in Latin America (OPANAL) and to the IAEA, concerning nuclear activity on their territory. Any other reports made to the IAEA are also to be sent to OPANAL. Provision is made as well for transmission of reports to the Organization of American States (OAS).

The Secretary-General of OPANAL can request further information from any party under Article 15. Both the IAEA and the Council of OPANAL (through the Secretary-General) can conduct special inspections under Article 16, the latter on request of any state party. Such inspections are obligatory, and the access of inspectors to all facilities is to be full and free. Article 16 is also noteworthy because it provides a mechanism for finding undeclared facilities.

Article 18 provides procedures for the conducting of PNEs. Prior notification to the IAEA is required giving the date, nature of the device, place and yield. Personnel from OPANAL and the IAEA are to observe all preparations and the test itself and the observers are to have unrestricted access to the test area.

Complaints can be lodged with OPANAL (Article 16). The General conference of OPANAL can if necessary refer the complaint to the UN Security Council or General Assembly, or to the OAS (Article 20).

Text of Main Verification Related Provisions:

Article 12.

Control System

1. For the purpose of verifying compliance with the obligations entered into by the Contracting Parties in accordance with article 1, a control system shall be established which shall be put into effect in accordance with the provisions of articles 13-18 of this Treaty.

2. The control system shall be used in particular for the purpose of verifying:

(a) That devices, services and facilities intended for peaceful uses of nuclear energy are not used in the testing or manufacture of nuclear weapons;

(b) That none of the activities prohibited in article 1 of this Treaty are carried out in the territory of the Contracting Parties with nuclear materials or weapons introduced from abroad, and

(c) That explosions for peaceful purposes are compatible with article 18 of this Treaty.

Article 13.

IAEA Safeguards

Each Contracting Party shall negotiate multilateral or bilateral agreements with the International Atomic Energy Agency for the application of its safeguards to its nuclear activities. Each Contracting Party shall initiate negotiations within a period of 180 days after the date of the deposit of its instrument of ratification

of this Treaty. These agreements shall enter into force, for each party, not later than eighteen months after the date of the initiation of such negotiations except in case of unforeseen circumstances or force majeure.

Article 14.

Reports of the Parties

1. The Contracting Parties shall submit to the Agency and to the International Atomic Energy Agency, for their information, semi-annual reports stating that no activity prohibited under this Treaty has occurred in their respective territories.

2. The Contracting Parties shall simultaneously transmit to the Agency a copy of any report they may submit to the International Atomic Energy Agency which relates to matters that are the subject of this Treaty and to the application of safeguards.

3. The Contracting Parties shall also transmit to the Organization of American States, for its information, any reports that may be of interest to it, in accordance with the obligations established by the Inter-American System.

Article 15.

Special reports requested by the General Secretary

1. With the authorization of the Council, the General Secretary may request any of the Contracting Parties to provide the Agency with complementary or supplementary information regarding any event or circumstance connected with compliance with this Treaty, explaining his reasons. The Contracting Parties undertake to co-operate promptly and fully with the General Secretary.

2. The General Secretary shall inform the Council and the Contracting Parties forthwith of such requests and of the respective replies.

Article 16.

Special inspections

1. The International Atomic Energy Agency and the Council established by this Treaty have the power of carrying out special inspections in the following cases:

(a) In the case of the International Atomic Energy Agency, in accordance with the agreements referred to in article 13 of this Treaty;

(b) In the case of the Council:

(i) When so requested, the reasons for the request being stated, by any Party which suspects that some activity prohibited by the Treaty has been carried out or is about to be carried out, either in the territory of any other Party or in any other place on such latter Party's behalf, the Council shall immediately arrange for such an inspection in accordance with article 10, paragraph 5.

(ii) When requested by any Party which has been suspected of or charged with having violated this Treaty, the Council shall immediately arrange for the special inspection requested in accordance with article 10, paragraph 5.

The above requests will be made to the Council through the General Secretary.

2. The costs and expenses of any special inspection carried out under paragraph 1, sub-paragraph (b), sections (i) or (ii) of this article shall be borne by the requesting Party or Parties, except where the Council concludes on the basis of the report on the special inspection that, in view of the circumstances existing in the case, such costs and expenses should be borne by the Agency.

3. The General Conference shall formulate the procedures for the organization and execution of the special inspections carried out in accordance with paragraph 1, sub-paragraph (b), sections (i) and (ii) of this article.

4. The Contracting Parties undertake to grant the inspectors carrying out such special inspections full and free access to all places and all information which may be necessary for the performance of their duties and which are directly and intimately connected with the suspicion of violation of this Treaty. If so requested by the authorities of the Contracting Party in whose territory the inspection is carried out, the inspectors designated by the General Conference shall be accompanied by representatives of said authorities, provided that this does not in any way delay or hinder the work of the inspectors.

5. The Council shall immediately transmit to all the Parties, through the General Secretary, a copy of any report resulting from special inspections.

6. Similarly, the Council shall send through the General Secretary to the Secretary-General of the United Nations, for transmission to the United Nations Security Council and General Assembly, and to the Council of the Organization of American States, for its information, a copy of any report resulting from any special inspection carried out in accordance with paragraph 1, sub-paragraph (b), sections (i) and (ii) of this article.

7. The Council may decide, or any Contracting Party may request, the convening of a special session of the General Conference for the purpose of considering the reports resulting from any special inspection. In such a case, the General Secretary shall take immediate steps to convene the special session requested.

8. The General Conference, convened in special session under this article, may make recommendations to the Contracting Parties and submit reports to the Secretary-General of the United Nations to be transmitted to the United Nations Security Council and the General Assembly.

Article 20.

Measures in the event of violation of the Treaty

1. The General Conference shall take note of all cases in which, in its opinion, any Contracting Party is not complying fully with its obligations under this Treaty and shall draw the matter to the attention of the Party concerned, making such recommendations as it deems appropriate.

2. If, in its opinion, such non-compliance constitutes a violation of this Treaty which might endanger peace and security, the General

Conference shall report thereon simultaneously to the United Nations Security Council and the General Assembly through the Secretary-General of the United Nations, and to the Council of the Organization of American States. The General Conference shall likewise report to the International Atomic Energy Agency for such purposes as are relevant in accordance with its Statute.

 D2(I76)

Proposal Abstract D2(I76)

1. **Arms Control Problem:**
   (a) Regional arms control - nuclear weapons free zone
   (b) Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Complaints procedure - consulation and cooperation
   - referral to new international body
   - referral to Security Council
   - referral to General Assembly

   (c) National self-supervision
   (d) International control organization

3. **Source:**
   Special Report of the Conference of the Committee on Disarmament. "Comprehensive study of the question of nuclear weapons free zones in all its aspects", UN Document A/10027/Add. 1, 1976. See especially Chapter 5 "Verification and Control", pp. 43-47.

4. **Summary:**
   The Special Report describes the general requirements for NWFZ agreements. The following is a summary of the report's discussion on verification and control systems.

   The precise nature of the verification and control system will vary with region and type of obligations incorporated into the agreement. The system should include provisions for verifying compliance and provisions for settlement of disputes. It should also include fact-finding machinery, a procedure for consultations between states and a forum for multilateral consultations.

   There are two tasks regarding verification of an NWFZ agreement. One is to ensure that zonal states do not develop or produce nuclear weapons. The other is to ensure that the zone is free of nuclear weapons introduced from outside sources.

   The first verification task can be achieved through the application of IAEA safeguards to all nuclear material in zonal states. It is preferable that <u>all</u> nuclear activities, not merely particular ones, be subject to the safeguards. Furthermore, present IAEA safeguards only monitor declared nuclear activities, hence it must be ensured that all nuclear activities in the zone have in fact been declared to the IAEA.

   The second verification task would be undertaken by machinery additional to the IAEA. This body's duties may include inspection of military installations, naval vessels and military aircraft within the zone. Existing regional or international organizations might undertake these responsibilities, otherwise it might be preferable to

establish standing regional bodies to implement those verification procedures not falling to the IAEA. One of the functions of such a regional body would be to monitor and coordinate the work of the national authorities responsible for verification within each state. Reciprocal investigation and inspection either directly or through the standing regional body and detailed consultation procedures would be important for settling disputes. A multilateral body would have the task of considering the reports of the standing control agency. It would also consider disputes over possible non-compliance when consultations between parties had failed. However, the parties should continue to have the right to refer complaints to the Security Council, General Assembly or other international body.

It is also desirable that one element of the verification system be a provision requiring states is a zone to apply adequate standards of physical protection to the nuclear material in order to prevent theft.

Inspections would be an integral part of the IAEA element of the system. A standing control agency could also have the power to carry out both routine and ad hoc inspections concerning obligations not verified by the IAEA.

It might be desired in some regions to assign all verification responsibilities to a special organ of the IAEA. This, however, would require amendment to the IAEA statute. On the other hand creation of ad hoc agencies might be useful for organizing the execution of the overall verification system.

 D3(G64)

Proposal Abstract D3(G64)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material 'cutoff'

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices
                                                     - sampling
   (c) International exchange of information - declarations.

3. **Source:**
   United States. "Working paper on inspection of a fissionable material cutoff". ENDC/134, 25 June 1964.

4. **Summary:**

The procedures described might, according to this paper, be applied by the IAEA regarding declared facilities, though the IAEA's organization and procedures would have to be strengthened. Inspection to detect undeclared facilities would be conducted on an adversary basis.

Each nuclear power would declare, annually:

(1) all U-235 separation plants, chemical separation plants and reactors, and
(2) the production of fissionable material needed for allowed uses and production schedules for each facility continuing to operate.

Each nuclear stable would have the right to question the declaration of another and if the other did not satisfactorily justify its declaration, to withdraw from the treaty.

Inspection of shutdown production facilities would be relatively easy and foolproof. After an initial inspection to ensure the facility had been shutdown, subsequent inspections would be irregular and with only a few days notice.

U-235 separation plants would have to be inspected to ensure only declared plants were operating and doing so within declared limits. Inspection would involve:

(1) ground access to the perimeter of the facilities and continuous observation of the perimeter,
(2) measurement of electrical power input into the plant,
(3) measurement of uranium input and output, and
(4) sampling of uranium tailings.

Regarding reactors, the nuclear powers should agree to accept IAEA inspection on a phased basis or a similar inspection scheme.

Chemical separation plants produce plutonium, U-233 and unconsumed uranium from spent reactor fuel. Close monitoring is necessary. Inspectors would require complete access to the facility at all times. Procedures would provide for:

(1) a design review,

(2) maintenance of adequate records and submission of reports, and

(3) inspections to account for material and to detect diversion.

Alternatively, a similar amount of material of the same type not previously subject to international safeguards might be placed under such safeguards.

There would be a limited number of adversary inspections conducted of suspected undeclared facilities. These would involve internal inspection of the plant or, in the case of sensitive facilities, appropriate external inspection procedures such as environmental sampling, external observation and measurement of electrical power consumption. The inspected party could take reasonable precautions to prevent observation of sensitive activities by the inspectors provided they could still determine whether or not prohibited activities were occurring. A procedure for initiation of these inspections would need to be developed.

 D4(G66)

Proposal Abstract D4(G66)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material "cutoff"

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   United States. "Working paper on transfer of fissionable material obtained by the destruction of nuclear weapons". ENDC/172, 8 March 1966.

4. **Summary:**
   This proposal for the destruction of nuclear weapons was linked to an American proposal for a "cutoff" of fissionable material used in weapons. The fissionable material obtained from the destruction of nuclear weapons would be transfered to peaceful purposes under IAEA or similar safeguards. The US would destroy a sufficient number of its nuclear weapons to obtain 60,000 kg of U-235. The Soviet quota would be 40,000 kg. Agreed amounts of plutonium would be obtained in a similar manner.

   The nuclear weapons to be destroyed would be transported to designated depots for disassembly and destruction. The destruction would be demonstrated to the nationals of both parties and to neutral observers in accordance with agreed procedures. Demonstration procedures to be acceptable would have to ensure that no confidential information, vital to national security or likely to lead to nuclear proliferation, was disclosed.

Proposal Abstract D5(G69)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material "cutoff"

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   United States. ENDC/PV.401, 8 April 1969.

4. **Summary:**
   The "cutoff" proposal is intended to restrict the military use of fissionable material. The essential elements of this proposal are:
   (1) a halt of all production of fissionable material for military purposes,
   (2) continued production only for peaceful uses, and
   (3) the use of the IAEA to safeguard the nuclear material in each state's peaceful nuclear activities and to verify the continued shutdown of closed fissionable materials production facilities.

   It is this third element which is a departure from previous American proposals which involved substantial elements of adversary inspection, especially with regard to the search for undisclosed facilities.* The US was, at the time of this proposal, prepared to accept the approach to verification adopted in the Non-Proliferation Treaty for non-nuclear weapons states, that is, use of IAEA safeguards and inspection.

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* See, for example: ENDC/134, June 26, 1964 (D3(G64)); ENDC/172, March 8, 1966 (D4(G66)); and ENDC/174, April 14, 1966 (I6(G66)).

D6(G79)

Proposal Abstract D6(G79)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable materials 'cutoff'

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) International exchange of information - declarations

3. **Source:**
   Canada. CD/PV.39, 5 July 1979.
   See also: - CD/PV.4, 25 January 1979.

4. **Summary:**

   Canada believes that several preparatory steps are necessary before any ban on the production of fissionable materials takes place. These include:

   (1) collection of accurate information on the total production of fissionable material and production facilities;
   (2) the declaration of ceilings on stocks of fissionable material for weapons purposes; and
   (3) the expansion of existing verification procedures especially the administration of full scope safeguards on a non-discriminatory basis.

   The key to the operation of the cutoff is confidence in full disclosure and in accurate verification.

5. **Selected Comments of States:**

   Several other countries expressed ideas similar to Canada's. Australia (CD/PV.28, 19 April 1979; PV.79, 17 April 1980) stated that such a ban would involve the development of a comprehensive system of full-scope safeguards to be administered by the IAEA and the application of such a safeguards regime to all peaceful nuclear facilities in both non-nuclear weapons states and nuclear weapon states. The Netherlands (PV.28) suggested that the nuclear safeguards system of the IAEA could be applied to the whole peaceful nuclear fuel cycle of the nuclear weapon states together with the transfer of all military enrichment and reprocessing plants to the peaceful cycle. An important feature of this idea is that all countries would accept the same type of verification, removing a discriminatory feature of present safeguards application. Japan (CCD/PV.801, 17 August 1978) also supports the extension of IAEA safeguards to the nuclear weapons states.

Proposal Abstract D7(A82)

1. Arms Control Problem:
   (a) Nuclear weapons - fissionable materials "cutoff"
   - comprehensive test ban
   (b) Chemical weapons - production
   - stockpiling

2. Verification Type:
   (a) On-site inspection - IAEA safeguards
   (b) Remote sensors
   (c) Seismic sensors

3. Source:
   Fischer, D.A.V. "Safeguards - A Model for General Arms Control?" IAEA Bulletin 24, no.2 (June 1982): 45-49.
   See also: - International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (abstract D12(I72)).

4. Summary:
   The author explores the possibility of using an IAEA safeguards type system for monitoring arms control agreements other than the NPT, particularly an agreement on the production of chemical weapons. He cautions, however, that the safeguards system is different from other approaches to verification for the following reasons:
   (1) IAEA safeguards verify a potentially worldwide peaceful activity whereas arms control and disarmament agreements usually cover purely military activities involving a small number of countries or even only two countries;
   (2) the IAEA verifies declared facilities only and is not permitted to search for undeclared facilities, whereas some other verification regimes permit searches at least on a limited scale to investigate unexplained activities or to find undeclared facilities; and
   (3) IAEA safeguards do not inhibit the military activities of the nuclear-weapon states or the non-explosive military activities of the non-nuclear-weapon states party to the NPT.

   Despite these differences, there are prospects for the further application of IAEA-type safeguards. An important accomplishment has been obtaining the acceptance of the principle of institutionalized on-site inspections. Containment and surveillance techniques may have wide applicability, but materials accountancy would be useful only for verifying prohibitions of non-nuclear armaments which use material with dual military and peaceful purposes.

Materials accountancy would have only limited applicability. It could be used to monitor a halt in the production of plutonium and highly enriched uranium for weapons in the military reactors, reprocessing plants and enrichment facilities of the nuclear-weapon states. The production of certain chemical warfare agents could also be monitored, but this poses considerable problems. The physical qualities of chemical agents do not lend themselves to precise measurement in the same way that the qualities of radioactive materials do. The ease with which chemical processes can be altered and the development of binary weapons create further problems for verification. Nevertheless, certain aspects of the IAEA safeguards system could be useful in a verification regime for chemical weapons. These include:

(1) a state system of accounting and control of materials which is verified by an independent body;
(2) state responsibility for reporting to an international body;
(3) technical procedures for records, reports and inspections;
(4) the legal hierarchy of a treaty, a safeguards system and agreements between states and the international control organization;
(5) the classification of inspections into three categories: ad hoc inspections for the initial phase; routine inspections for normal operations; and special inspections for unusual events; each category having different rights of access;
(6) the designation of "strategic points" to which routine inspections are confined; and
(7) sampling and analysis techniques.

Containment and surveillance instruments and techniques such as seals, surveillance cameras, closed-circuit TV and RECOVER may be useful to seal-off and monitor moth-balled plants or stocks of chemical weapons awaiting conversion or destruction.

Safeguards techniques do not appear relevant to seismic verification of a CTB, but IAEA expertise in developing tamper-proof instruments might be applicable to ensuring the integrity of unattended seismic monitoring devices.

There are two overriding considerations which reduce the likelihood of acceptance of a safeguards type verification regime for any nuclear weapon arms control agreement. First, non-intrusive verification techniques will probably be preferred for monitoring nuclear arms control agreements. National technical means of verification will, therefore, be utilized. Second, because of concern for national security and the release of sensitive military information, states are not likely to submit to international inspection. Verification measures will be conducted by the super-powers themselves or by other nuclear weapon states. On-site inspections, if accepted, would probably consist of a limited number of challenge inspections each year. However, containment and surveillance techniques might be used during the transition period under a nuclear arms control agreement under which facilities have to be moth-balled prior to destruction or conversion to peaceful uses.

Proposal Abstract D8(A85)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material 'cutoff'

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Remote sensors - satellite
   - ELINT
   (c) Non-physical/psychological inspection

3. **Source:**
   Von Hippel, F., David Albright and Barbara Levi. "Stopping the Production of Fissile Materials for Weapons". Scientific American 253, no.3 (September 1985): 40-47.

4. **Summary:**

The authors maintain that "if the superpowers are willing to accept inspections and other safeguards on their nuclear activities that are not related to weapons, both a cutoff in production of fissile material for nuclear weapons and substantial reductions in the quantities of fissile materials already in the stockpiles could be satisfactorily verified" (p.47). They define adequate verification as "the ability to detect within a few years any set of clandestine activities large enough to increase one of the superpower stockpiles at a rate greater than 1 percent per year" (pp.43-44). They suggest that this would be a "significant restraint" because it constitutes a production rate about one tenth as large as past peak production rates. Any smaller violations would not provide sufficient benefits to warrant the risk of detection.

Verification would involve monitoring two types of activities. The first task is ensuring that significant quantities of fissile material are not diverted to weapons from legitimate activities. The second is ensuring that there are no significant clandestine production facilities.

IAEA safeguards could be used for the first verification task. IAEA safeguards have a standard of stringency which far exceeds the requirements of this fissionable material "cutoff" proposal, both in terms of detection limit and detection time. IAEA safeguards are designed to detect within days or months the diversion of enough fissile material to manufacture a single nuclear weapon. This amount is deemed to be eight kilograms of plutonium or twenty-five kilograms of weapon-grade uranium. In contrast, the 'cutoff' proposal's significant quantity would be about five tonnes of weapon-grade uranium or one tonne of plutonium (based on a one percent increase of estimated US stockpiles) and the detection time is specified as "a few years". IAEA safeguards would therefore be more than adequate for verification purposes.

The IAEA safeguards method uses materials accountancy to monitor inventories of nuclear materials as reported to the IAEA by member states. Periodic inspections confirm the correspondence between actual and reported inventories. Radiation measurements and other non-destructive measurements verify that there has been no substitution of "counterfeit" fuel. Tamper-proof seals on storage containers and camera surveillance verify that inactive fissile material has not been removed from storage.

There are three types of nuclear reactors which must be monitored. The first type is American and Soviet nuclear power reactors which currently use low enriched uranium in fresh fuel and do not use plutonium recovered from spent fuel. These reactors do not create significant opportunities for using diverted nuclear materials because, even if diverted, the material would require enrichment or reprocessing before it could be used in weapons and such major operations would be detected. The second type are naval propulsion reactors. Since neither the US nor the USSR is likely to allow inspections of ships or the facilities which produce fuel for naval reactors, alternative arrangements would be necessary. One possibility is an agreement between the superpowers on the amount of U-235 which could be produced for use in naval reactors. The U-235 would be produced at safeguarded plants and an equivalent amount of irradiated enriched uranium would have to be returned to another safeguarded facility within a specified period of time. The third type of reactors are those whose fuel cycles produce Tritium (a source of neutrons to enhance the fission efficiency of American nuclear weapons and for the production of the "neutron bomb"). Tritium must be replenished even if stockpiles are frozen because of its 12-year radioactive half-life, but this could be accomplished by one reactor which could be safeguarded.

The prospects for the application of safeguards have improved recently with the Soviet announcement in 1982 that the USSR would be willing to place some of its peaceful nuclear installations under IAEA control. A limited initial agreement was concluded by the IAEA and the USSR in March 1985. However, the Soviet reactors which can produce both power and weapon-grade plutonium will not be subject to safeguards.

The second verification task, ensuring that no production facilities are secretly built, can be accomplished by remote sensing from satellites. Telescopes sensitive to infra-red radiation emitted by warm surfaces can detect the energy produced by hidden activities. For example, a set of clandestine reactors capable of producing one tonne of plutonium per year would generate about three million kilowatts of waste heat - equivalent to the output of a city of 300,000 people. Satellite sensors capable of detecting the presence or absence of ceiling insulation in a single-family house would certainly be able to detect energy outputs of such magnitude. Furthermore, the construction of plutonium production reactors or fuel reprocessing facilities would entail projects of such a size that concealment from satellite observation would be extremely difficult.

Supplementary information such as internal reports, interception of radio and microwave transmissions and interviews with émigrés would further strengthen verification capabilities.

Identification of gas-centrifuge plants and laser isotope enrichment plants might not be possible from satellite photos alone, therefore a larger intelligence effort would be necessary, but it would still be possible to detect the large projects involved in the construction of these plants.

Existing fissile materials could be disposed of by "burning" them in nuclear-power reactors if a reduction in weapons stockpiles were negotiated. Further reductions, beyond 50 percent for example, would necessitate a greater exchange of information and more refined analyses because small violations would take on greater importance with smaller stockpiles.

Proposal Abstract D9(T68)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation
   - peaceful nuclear explosions

2. **Verification Type:**
   a) On-site inspection - IAEA safeguards (Article 3)
   b) Review conference (Article 8(3))

3. **Source:**
   Treaty on Non-Proliferation of Nuclear Weapons. (Non-Proliferation Treaty).
   Concluded: 1 July 1968.
   Signed by Canada: 32 July 1968
   Entered into force: 5 March 1970.
   Number of parties as of 31 December 1986: 131.

4. **Summary:***

   The NPT prohibits transfer of nuclear weapons or explosive devices by nuclear weapon states to any recipient whatsoever (Article 1). Non-nuclear weapon states also agree not to receive such devices nor to develop or manufacture them (Article 2).

   Concerning verification, non-nuclear weapons states undertake to conclude safeguards agreements with the IAEA "with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices" (Article 3(1)). Such safeguards under the NPT are to apply to "all source and special fissionable material in all peaceful nuclear activities within the territory" of the non-nuclear weapon state, or carried out under its control anywhere.

   Parties also undertake not to provide "(a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear weapon state" whether a party to the NPT or not, unless the source or special fissionable material is subject to IAEA safeguards (Article 3(2)).

   The safeguards required by Article 3 are to be implemented in such a way as not to affect the inalienable rights of parties to develop, produce and use nuclear energy for peaceful purposes nor the right to participate in exchange of material, equipment, or information on the peaceful use of nuclear energy (Article 3(3) and Article 4).

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* See also abstract D16(175) dealing with the NPT review conferences.

Non-nuclear weapon states parties conclude safeguards agreements with the IAEA either individually or in groups of states. Negotiation for such agreements must commence immediately upon deposit of instruments of ratification or accession and the agreements must enter into force not later than 18 months after negotiations begin (Article 3(4)).

Article 5 allows for making available to non-nuclear the benefits of PNEs but under "appropriate international observation and through appropriate international procedures ..." established by a body on which there would be "adequate representation of non-nuclear weapon states".

Text of Main Verification Relevant Provisions:

Article 3

1. Each non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Procedures for the safeguards required by this article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or is outside any such facility. The safeguards required by this article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere.
2. Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed to prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this article.
3. The safeguards required by this article shall be implemented in a manner designed to comply with article IV of this Treaty, and to avoid hampering the economic or technological development of the Parties or international cooperation in the field of peaceful nuclear activities, including the international exchange of nuclear material and equipment for the processing, use or production of nuclear material for peaceful purposes in accordance with the provisions of this article and the principle of safeguarding set forth in the Preamble of the Treaty.
4. Non-nuclear-weapon States Party to the Treaty shall conclude agreements with the International Atomic Energy Agency to meet the requirements of this article either individually or together with other States in accordance with the Statute of the International Atomic Energy Agency. Negotiation of such agreements shall commence within 180 days from the original entry into force of this Treaty. For States depositing their instruments of ratification of accession after the 180-day period, negotiation of such agreements shall commence not later than the date of such deposit. Such agreements shall enter into force not later than eighteen months after the date of initiation of negotiations.

Proposal Abstract D10(I68)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev.2, 16 September 1968.
   See also: - "IAEA activities under Article III of the NPT". NPT/CONF.II/6, 14 July 1980.

4. **Summary:**
   INFCIRC/66/Rev.2 outlines the elements to be included in Safeguards Agreements between the IAEA and states which are not parties to the NPT. This model represents one of the two basic safeguards systems operated by the IAEA.* In contrast to the INFCIRC/153 system the objective here is to ensure that special fissionable and other materials, services, equipment, facilities and information are not used in such a way as to further any military activity (paragraph 2 of INFCIRC/66). It applies only to specific imports of nuclear materials, equipment and technology, not to the entire peaceful nuclear industry in a state. Also, it seeks to prevent use of the safeguarded materials for any military purpose not simply for nuclear explosions.

   Many of the elements found in the INFCIRC/153 safeguards system are found also in this system including the requirements to provide design information to the Agency (paragraphs 30-32), to keep accounting and operational records (pa. 33-36), to implement a system of reports to the Agency (pa. 37-44), and to permit Agency inspections (pa. 45-54). The Agency is also obligated to prevent disclosure of sensitive information (pa. 13-14).

   Several differences between the two systems should be pointed out, however. First, generally, the specifications in INFCIRC/153 for the elements outlined above tend to be considerably more detailed than in INFCIRC/66. Second, there is no explicit mention of a national accounting system nor are any specific requirements for such a system specified in INFCIRC/66. The central importance of the national accounting system to IAEA efforts does not come through as it does in INFCIRC/153. Nor are the containment and surveillance elements of the safeguards system mentioned.

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* For the other model (INFCIRC/153), see abstract D12(I72).

There are fewer limitations (pa. 45-54) placed upon the access allowed inspectors in INFCIRC/66. The exemptions from safeguards which are permitted differ somewhat between the two documents with INFCIRC/153 being more generous, though amounts in both cases are small. Provisions are present in INFCIRC/66 which allow for suspension of safeguards in some circumstances unlike INFCIRC/153 (pa. 24-15).

The circumstances under which safeguards terminate also differ somewhat with INFCIRC/153 being more restrictive (pa. 26-27). In the INFCIRC/66 system there is no clear indication of when nuclear material becomes susceptible to safeguards in contrast to the NPT system. International transfers are also treated differently; in INFCIRC/66 the main effect of an international transfer is to terminate safeguards (pa. 28 and 26).

No provisions for the settlement of administrative disputes are outlined in INFCIRC/66. Non-compliance can lead to similar sanctions by the Agency as in INFCIRC/153.

Special procedures for reactors (pa. 56-58) nuclear material outside principal nuclear facilities (pa. 59-68), reprocessing plants (Annex I) and conversion and fabrication plants (Annex II) are also spelled out in INFCIRC/66.

 D11(I70)

Proposal Abstract D11(I70)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. Safeguards Techniques. Proceedings of a Symposium held in Karlsruhe from 6-10 July 1970. 2 volumes. STI/PUB/260.

4. **Summary:**

   The papers in these volumes review experience gained in applying safeguards. Treatment is more theoretical than in Safeguarding Nuclear Materials* of 1975. There are 66 papers (60 English, 4 French and 2 Russian) broken down into the following chapters:

   Volume I - Safeguards Experiments and Experience (17 papers),
   - Design of Safeguards Material Control Systems (11),
   - Material Control System Experience (5), and
   - Panel on Assessment of Burn-Up, Isotopic Abundance and Related Measurements at the Reprocessing-Input Point (7).

   Volume II - Quantitative Safeguards Techniques (10),
   - Qualitative Safeguards Techniques (4),
   - Views on System Analysis (3), and
   - Systems Analysis (9).

   Each paper is accompanied by an abstract in English.

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* See abstract D15(I75).

Proposal Abstract D12(I72)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev. 1, June 1972.
   See also: - Safeguards. Vienna: IAEA, (1977?).
   - "IAEA activities under Article III of the NPT". NPT/CONF. II/6, 14 July 1980.

4. **Summary:** *

   INFCIRC/153 outlines the elements which should be included in Safeguards Agreements between the IAEA and individual states or groups of states made pursuant to the the Non-Proliferation Treaty. This model sometimes referred to as 'full-scope' safeguards represents one of the two basic safeguard systems operated by the IAEA.** The object of the NPT safeguards regime is to monitor all source or special fissionable material in all peaceful nuclear activities within the territory of a state or under its jurisdiction or control anywhere so as to ensure that such material is not diverted to produce nuclear explosives (paragraph 1 of INFCIRC/153).

   Three fundamental principles underlie the model safeguards system represented by INFCIRC/153. First, the basic intent is to deter the diversion of nuclear material through the risk of early detection (pa. 28). Second, this is to be accomplished with the minimum interference possible so as not to impede the peaceful use of atomic energy (eg. pa. 4). Finally, the basis of the IAEA safeguards system lies with the comparison between the information provided by the inspected party and that provided through the independent verification and inspection performed by the Agency (eg. pa. 7 and 31).

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* The following description is based primarily on the Safeguards pamphlet.

** For the other model (INFCIRC/66/Rev.2), see abstract D10(I68).

In the NPT safeguards regime there are three key legal documents. There is first, the Safeguards Agreement between the Agency and the state involved, which contains an undertaking by the state to accept safeguards, a statement regarding general exemption, an outline of the requirements of each party and the safeguards procedures to be applied. Subsidiary Arrangements between the Agency and the state provide further details for executing the Agreement (pa. 39). Finally, Facility Attachments detail the safeguards to be applied to each facility.

Material Accountancy:

Material accountancy is the prime means of Agency verification (pa. 29). It involves the collection of measurements and other determinations which enable the state and the IAEA to keep track of the location and movement of nuclear material. Specifically, in consists of "the initial determination of physical inventory for a material balance area; the perpetuation of a book inventory based on the original determination and subsequent measured inventory changes; verification and updating of the book inventory by periodic physical inventory measurements; and the submission by the State of reports to the IAEA to enable the Agency to maintain a parallel set of accounts which are subject to verification and particularly comparison with the records kept at the facility" (p. 24, Safeguards). It is the comparison between book inventory and actual physical inventory of nuclear material which forms the basis of material accountancy. Differences are termed "material unaccounted for" which are analyzed to determine whether losses or diversions have occurred.

The main focus of material accountancy is the material balance area (MBA) which is an area such that all material entering or leaving is measureable and in which an inventory of the material situated there can be determined when necessary. Measurements are taken at key measurement points (KMPs). Both MBAs and KMPs are specified in the Facility Attachments.

The IAEA relies heavily on the national accounting and control system of the state for accountancy data (pa. 31). The Agency does, however, require that a number of features be incorporated into the national system (pa. 32) including:

(1) a measurement system for determining flow and inventory of nuclear material,
(2) a means for evaluating measurement accuracy,
(3) procedures for identifying and evaluating shipper/receiver measurement differences,
(4) procedures for taking physical inventory,
(5) procedures for evaluating unmeasured inventory and losses,
(6) a system of reports and records for each MBA,
(7) a means for checking accounting procedures, and
(8) procedures for submission of reports to the IAEA.

The form of the accounting records kept by the national system is at the discretion of the plant operator provided that several features are present (pa. 56 and 57) including:

(1) a record of inventory changes,
(2) a record of measurement results, and
(3) a record of adjustment and correction.

In addition, the Agency requires the facility to maintain operating records for each MBA in which several specific types of data must be recorded (pa. 58).

A system of reports to the IAEA is also demanded of the facility operator (pa. 59-69). The initial report is submitted within 30 days of the last day of month during which the Safeguards Agreement enters into force and it forms the basis of the Agency's parallel accounting system. It is essentially a listing of the physical inventory of nuclear material in each MBA. The Agency can visit the facility to verify the information in the initial report as it can with regard to other types of reports.

The inventory changes report informs the IAEA of material movements. Notes attached to this report indicate the operations performed during the movements.

Each facility periodically takes a physical inventory of its nuclear material. When this is done the facility operator should submit a material balance report for each MBA. One of the items of data to be included in this report is "material unaccounted for".

Finally, if evidence is uncovered that nuclear material may have been lost or if any containment measure has been affected, a special report to the IAEA is mandatory.

The key to verification in the IAEA safeguards system is the right to conduct inspections (pa. 71-82). The basic purpose of all three types of IAEA inspections - ad hoc, routine and specialist - is to perform independent measurements and observations for comparison with the information submitted by the state. Secondarily, inspections also permit the application and servicing of IAEA containment and surveillance procedures. The frequency, scope and limitations of inspections depend on the type of material involved and the sophistication of facility management and national control schemes. Inspections may be periodic or continuous or without notice as long as agreed constraints are not exceeded. Regarding costs, generally each party bears its own expenses.

Inspectors are chosen for their competence and integrity with consideration also given to an equitable geographic representation. The Agency's Director General submits names of potential inspectors to the state to be inspected. The state has the right to refuse any inspector, however, persistent refusal of candidates will be brought to the attention of the Agency's Board of Governors (pa. 9).

When an inspection is decided upon, the state is notified and given relevant information about the visit. During the inspection, the Agency's inspectors might:

(1) examine records,
(2) make independent measurements,
(3) check measurement and control equipment,

(4) observe facility measurement, sampling and calibration procedures, and
(5) request duplicate or additional samples and measurements.

Inspections are restricted in that inspectors:
(1) are accompanied by state representatives,
(2) can not operate any equipment, and
(3) do not enjoy unlimited access.

The Agency is also obligated to prevent disclosure of commercially sensitive information acquired in the course of exercising its duties (pa. 5).

Containment and Surveillance:

In addition to material accountancy, the IAEA safeguards system employs two other verification means: containment and surveillance. Containment takes advantage of existing structural characteristics at facility and involves the use of seals and other devices to prevent changes in the contents of an area without the Agency's knowledge. Surveillance unlike containment involves detection rather than prevention of the movement of material. It includes both human and instrumental observations to monitor plant activities.

Starting Point, Termination and Exemptions:

Safeguards are applied to nuclear material when it reaches a certain composition or level of purity (pa. 34). They cease, generally, when either the material is sufficiently diluted so as to be non-recoverable or it is transferred out of the state (pa. 12). There are also provisions included in each Safeguards Agreement for several exemptions of material which would otherwise fall under safeguards (pa. 36-38). In addition, the NPT excludes from coverage nuclear material used in non-proscribed military activities and in non-nuclear activities.

The Design Review:

Practically, the first step in implementing NPT safeguards is the Design Review (pa. 42-58) during negotiations on the Subsidiary Arrangement when the state supplies the IAEA with information on the design of its existing facilities. The Design Review permits the Agency to identify the features of particular facilities which are relevant to safeguards application. On the bases of this design information the Agency defines MBAs and KMPs, establishes records, reports and verification requirements, and selects containment and surveillance techniques. The Agency is entitled to verify the accuracy of the design information provided by the state. The results of the Agency's Design Review are reflected in the particulars of the Facility Attachments which outline the operational details of safeguards at specific facilities.

International Transfers:

Special procedures are specified in INFCIRC/153 regarding safeguards requirements and procedures for the international transfer of nuclear materials under the NPT (pa. 91-97). As for other features of the NPT safeguards system, the Safeguards pamphlet provides useful tabular summaries of these provisions.

Disputes:

Provision is made for disagreements of an administrative nature to be submitted to the IAEA Board of Governors or to an arbitral tribunal (pa. 20-22). When the Agency is unable to verify non-diversion of safeguarded material the state may be required to take certain actions within a reasonable time to enable verification, or procedures for non-compliance may be initiated by the Board of Governors (pa. 18-19). These procedures include notification of IAEA member states and the UN Security Council and General Assembly. Ultimately, IAEA-sponsored material and technical assistance may be recalled and the violating state suspended from the IAEA.

Actual costs, number of inspections conducted and other details of the Agency's safeguards program are given in "IAEA activities under Article III of the NPT" cited above. These figures, which cover up to 1979, indicate that the implementation of safeguards is becoming a proportionately bigger share of IAEA activities.

 D13(G74)

Proposal Abstract D13(G74)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Sweden. CCD/PV.647, 30 July 1974.

4. **Summary:**
   The IAEA should extend its safeguards system to include a system of physical protection of all stockpiles of nuclear material. The Agency itself should stockpile excess material. Essentially, this means the internationalization of the management of nuclear material, to watch and protect it in order to prevent nuclear proliferation.

Proposal Abstract D14(A75)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
On-site inspection - IAEA safeguards

3. **Source:**
Sanders, Benjamin. Safeguards Against Nuclear Proliferation. Cambridge, Mass.: The MIT Press, 1975.
See also: - International Atomic Energy Agency. "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev.2, 16 September 1968 (see abstract D10(I68)).
- International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (see abstract D12(I72)).

4. **Summary:**
This book discusses the objectives and application of International Atomic Energy Agency safeguards. The author contends that all Agency safeguards, whether applied pursuant to the NPT (under INFCIRC/153) or as part of bilateral or multilateral arrangements (under INFCIRC/66/Rev.2), are designed to prevent or deter the proliferation of nuclear weapons. Both safeguards documents provide the legal basis for the IAEA to achieve its objectives, but it may be necessary to review and update INFCIRC/66/Rev.2 because it appears that some industrial nations have withheld acceptance of the NPT since they can continue to receive nuclear supplies under the INFCIRC/66/Rev.2 safeguards system. It would be useful to bring the document up to date with developments in accounting concepts, statistical methods and containment and surveillance techniques.

Research and development activities of the IAEA cover three areas. First, systems analysis is designed to solve operational problems and optimize the cost-effectiveness of safeguards. Second, development of methods and techniques proceeds with the goal of minimizing the intrusiveness of safeguards. Most of this work is contracted out by the Agency to research institutes in member states. Third, the IAEA tests techniques and methods and codifies the results with the assistance of member states. The IAEA "Grey Book" contains the results of these programs.

The safeguards system may be somewhat less than 100 per cent effective, but this is acceptable as long as the shortcomings of the system are kept in mind. The growth of the nuclear power industry, rather than making safeguarding more complicated, may in fact simplify the application of safeguards for the following reasons:

(1) safeguards can be applied with greater ease to strategically important stages of the fuel cycle as more countries acquire complete nuclear fuel cycles;

(2) more information will be available to the IAEA as more governments implement systems for accounting for and control of nuclear material; and

(3) increasing experience will allow the IAEA to develop better techniques and equipment.

Proposal Abstract D15(I75)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. Safeguarding Nuclear Material. Proceedings of a Symposium held in Vienna from 20-24 October 1975. 2 volumes. STI/PUB/408.

4. **Summary:**

The papers included in these volumes emphasize actual practical experience in the operation of material control system, non-destructive measurement techniques and safeguards procedures.

There are 86 papers, broken down into the following chapters:

Volume I
- General (4 papers),
- State Systems of Accounting and Control (11)
- Physical Protection of Nuclear Materials (3),
- Information Systems and Real-Time Material Control (10),
- Safeguards and Material Control Experience (9), and
- Probability and Safeguards (7).

Volume II
- Instrumentation and Measurement Methods (20),
- Containment and Surveillance (4),
- Non-Destructive Measurements (2),
- Measurements in Reprocessing Facilities (2),
- High-Temperature gas Reactors (3),
- Mixed-Oxide Fuels (6), and
- Non-Destructive Measurements of Reactors and Reactor Fuels (5),

Each paper is accompanied by an abstract in English.

Proposal Abstract D16(I75)

1. **Arms control Problem:**
   Nuclear weapons - proliferation
   - peaceful nuclear explosions
   - comprehensive test ban

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Review conference

3. **Source:**
   (a) Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons. "Final declaration". NPT/CONF/35/1, Annex 1, 1975.
   (b) Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons. "Final document". NPT/CONF. III/84/I, Annex I, 1985.
   See also: - United Nations. Press Release. NPT/56. 7 September 1980.*

4. **Summary:**
   <u>(1)(a) Review of Article 3 (1975)</u>

   The conference expressed the hope that all states having peaceful nuclear activities will establish and maintain effective accounting and control systems and welcomed the IAEA's readiness to assist states in so doing. It recommended intensified efforts towards standardization and the universality of application of IAEA safeguards while ensuring that safeguards agreements with non-nuclear weapons states not parties to the treaty, are of adequate duration, preclude diversion of any nuclear explosive devices and contain appropriate provision for the continuance of the application of safeguards upon re-export. The conference recommended that more attention be given to the improvement of safeguards techniques, instrumentation, data handling and implementation in order to ensure cost effectiveness.

   The conference urged the establishment of common export requirements concerning safeguards particularly through extending application of safeguards to all peaceful nuclear activities in importing states not parties to the Treaty. The conference urged further elaboration within the IAEA of concrete recommendations for the physical protection of nuclear material in use, storage and transit, including principles relating to the responsibility of states, with a view to ensuring a uniform, minimum level of effective protection for such material.

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* The second NPT Review Conference of July 1980 failed to reach agreement on a substantive final declaration. Instead it reproduced the working papers presented by various governments.

(b) Review of Article 3 (1985)

The Conference reaffirmed that IAEA safeguards play an important role in demonstrating that states are complying with their undertakings under the NPT, and consequently contribute to preventing the proliferation of nuclear weapons and other nuclear explosive devices. Reviewing past adherence to the Treaty, the Conference noted with satisfaction that parties have met the commitments in Articles 1-3 and this has greatly helped in preventing the spread of nuclear explosives. The Conference also expressed satisfaction that four of the five nuclear weapon states have voluntarily concluded safeguards agreements with the IAEA covering all or part of their peaceful nuclear activities. In order to pursue the goal of universal application of IAEA safeguards to all peaceful nuclear activities in all states, the Conference urged all non-nuclear weapon states not party to the Treaty to make an international legally-binding commitment not to acquire nuclear weapons or other nuclear explosive devices and to accept IAEA safeguards on all their peaceful nuclear activities. The Conference also specifically called upon the People's Republic of China to conclude a safeguards agreement with the IAEA.

The Conference commended the IAEA for its unobtrusive implementation of safeguards and expressed satisfaction that the IAEA had not detected any diversion of a significant amount of safeguarded nuclear material. Improvements in safeguards were welcomed by the Conference. Further improvements should be made which take account of advances in technology. The Conference recommended that the IAEA establish an effective system of international plutonium storage in accordance with Article XII(A)(5) of its statute. While urging the parties to the NPT to continue their political, technical and financial support of the IAEA safeguards system, the Conference also called upon the parties to assist the IAEA by efficiently operating the state systems of accounting for and control of nuclear material and by complying with all notification requirements in accordance with safeguards agreements.

(2)(a) Review of Article 4 (1975)

The conference recommended that any nuclear assistance agreements should give weight to adherence to the Treaty by the recipient states. In this connection measures of cooperation might include increased and supplemental voluntary aid provided bilaterally or through multilateral channels such as the IAEA's.

The conference recognized that regional or multinational nuclear fuel cycle centres may be an advantageous way to satisfy, safely and economically, the needs of many states while at the same time facilitating physical protection and the application of IAEA safeguards.

(b) Review of Article 4 (1985)

The Conference noted with satisfaction that, pursuant to a recommendation of the First Review Conference, the IAEA had established a mechanism to permit the channelling of extra-budgetary funds to projects additional to those Finances from the IAEA Technical Assistance and Cooperation Fund. The Conference also acknowledged the importance of international and multilateral cooperation in the operation and management of the back end of the fuel cycle.

Expressing its profound concern about the Israeli military attack on Iraq's safeguarded nuclear reactor on 7 June 1981, the Conference noted that such attacks pose a grave danger due to the release of radioactivity. The Conference encouraged parties to the NPT to be prepared to provide immediate peaceful assistance in response to a request by any other party to the NPT which is a victim of such an attack.

The Conference took note of demands made on South Africa and Israel to accede to the NPT, to accept IAEA safeguards on all their nuclear facilities and to pledge not to manufacture or acquire nuclear weapons or other nuclear explosive devices. Further demands that all states should suspend any cooperation which would contribute to the nuclear programme of South Africa and Israel were noted.

(3)(a) Review of Article 5 (1975)

Nuclear explosive services should be provided to non-nuclear weapons states by nuclear weapons states and be conducted under the appropriate international observation procedures called for in Article 5 and in accordance with other applicable international obligations. The IAEA is the appropriate international body through which PNEs should be made available to any non-nuclear weapon state. The IAEA is urged to commence consideration of the special international procedures contemplated in Article 5.

(b) Review of Article 5 (1985)

Although it reaffirmed the obligation of parties to the NPT to ensure that potential benefits from any peaceful applications of nuclear explosions are made available to non-nuclear weapon states party to the Treaty, the Conference pointed out that no such potential benefits have been demonstrated and that no requests for services related to the peaceful applications of nuclear explosions were received by the IAEA between the Second and Third NPT Review Conferences.

 D17(A77)

Proposal Abstract D17(A77)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   American Nuclear Society. Executive Conference on Safeguards. Proceedings of a Conference held at Cape Cod, Mass. from 16-19 October 1977. La Grange Park, Illinois: American Nuclear Society, 1977.

4. **Summary**

The conference discussed the International Fuel Cycle Evaluation (INFCE), International Atomic Energy Agency (IAEA) safeguards and the national safeguards systems of France, Japan, the Federal Republic of Germany, the United Kingdom, Euratom and the United States with greater emphasis on the US program. Twenty-one papers were presented and they are divided into the following sections:

(1) International safeguards objectives, status and unresolved issues (5 papers);
(2) United States government roles, programs and views on safeguards (3 papers);
(3) International and other national safeguards regulations, technology development and application programs (5 papers);
(4) United States safeguards regulation, technology development and application (5 papers); and
(5) An assessment of safeguards (3 papers).

Proposal Abstract D18(G77)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   - general
   (b) Remote sensors

3. **Source:**
   United States Congress. Office of Technology Assessment. Nuclear Proliferation and Safeguards. Washington, D.C.: 1977.

4. **Summary:**
   The report identifies three routes to proliferation:
   (1) diversion of material from civilian programs,
   (2) construction of facilities specifically designed to produce nuclear weapons materials, and
   (3) purchase or theft of fissile material.
   Of these, most attention has, in the past been paid to the first.

   Four levels of control effort are specified, one of which is the detection of attempts to acquire fissile material through the use of safeguards or intelligence activities. Safeguards are defined as "sets of regulations, procedures, and equipment designed to prevent and detect the diversion of nuclear materials from authorized channels" (p. 262). The report describes and evaluates US domestic safeguards as well as those of the IAEA. With regard to the latter, the report concludes that it appears the IAEA will succeed in developing and implementing improved equipment and techniques for monitoring light water reactors. Onload reactors such as CANDU may prove harder, requiring the stationing of observers at plants. With regard to enrichment and reprocessing plants, it is essential to develop advanced containment and surveillance systems. Given adequate manpower and technical and financial assistance the safeguards system should be able to improve as the size of facilities under safeguards increase.

   Several problems with the present IAEA safeguards system are identified:
   (1) the limited power of response of the IAEA,
   (2) restrictions imposed by proprietary interests,
   (3) failure of facility designs to integrate the application of safeguards, and
   (4) dependence on inspector quality and morale.

   A number of policy implications are also outlined in the report regarding the IAEA safeguards systems. First, safeguards technology could be quickly upgraded through more extensive use of

multi-redundant cameras, seals, and portal monitors with full-time remote alarm systems monitoring by inspectors. Current restrictions on the operations of cameras and recording devices could be lifted. New technology could and is being developed. Controls to prevent procedural lapses could be made more strict. Real-time accounting systems would also enhance the timeliness of detection.

The IAEA should also be assured that funding, staffing and technical competence are augmented at a rate commensurate with global expansion of nuclear facilities. This includes a high quality recruitment and training program as well as high salaries. New funding mechanisms to finance the IAEA might be considered such as a tax on nuclear power.

The IAEA should also be provided with the authority to search for undeclared facilities including the right to instigate unannounced field investigations with full access to the territory of a state. The IAEA safeguards should be extended to the civilian reactors of France, the USSR and the PRC.

Safeguards should also be extended to cover acquisition through imports or diversion of plutonium for military non-weapons purposes.

Agreement should be sought on a common plan of action and graded sanctions for safeguards violations.

A standard text for multilateral and bilateral safeguards agreements should be created. This would form a basis for supplier states to demand that recipients submit all their peaceful nuclear activities to safeguards.

The interface between IAEA safeguards and national materials accounting system should be improved such as through standardized measuring and accounting systems.

In addition to safeguards, national intelligence gathering capabilities are important, according to the report, especially for detecting undeclared dedicated facilities and purchase/theft routes to the acquisition of nuclear materials. Sources of intelligence include:
(1) political reporting from embassies,
(2) other human intelligence,
(3) monitoring communications,
(4) overflights,
(5) satellites, and
(6) atmospheric sampling.

Effective responses to violations will mean the pooling of nuclear intelligence.

 D19(I77)

Proposal Abstract D19(I77)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. Nuclear Power and Its Fuel Cycle. Proceedings of an International Conference held in Salzburg from 2-13 May 1977. 8 volumes. Volume 7: "Nuclear Power and Public Opinion, and Safeguards". STI/PUB/465.

4. **Summary**
   The 1977 conference in Salzburg discussed problems of the nuclear fuel cycle and the need for its integration on both a national and international level. The papers presented were intended mainly for senior planners involved in nuclear programme decision-making, but were of relevance to scientists and engineers also. Volume 7 of the proceedings contains papers dealing with nuclear safeguards. There are eighteen papers (14 in English, 2 in French and 2 in Russian) as well as transcripts of discussions of papers and a round table discussion on the effectiveness of safeguards. Each paper is accompanied by an abstract in English, French, Russian and Spanish.

Proposal Abstract D20(I78)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. Nuclear Safeguards Technology 1978. Proceedings of a Symposium held in Vienna from 2-6 October 1978. 2 volumes. STI/PUB/497.

4. **Summary:**

The papers from this symposium review accomplishments and remaining problems in the field of nuclear safeguards technology. There are 111 papers (96 English, 8 Russian and 7 French) divided into the following chapters:

Volume I - General Papers (5 papers),
- Facility Design Criteria for International Safeguards (5),
- Electronic Processing of Safeguards Information (3),
- Safeguards Technology for Uranium Enrichment Facility (4),
- Safeguards Technology for Fuel Fabrication Facilities (3),
- Safeguards for Nuclear Power Reactors (17),
- Containment and Surveillance (8), and
- Destructive and Non-Destructive Measurement Technology (8).

Volume II - Destructive and Non-Destructive Measurement Technology - continued (23),
- Safeguards Data Evaluation (6),
- Advanced Materials Control Concepts and Systems (8),
- Thorium/U-233 Fuel Cycles (4), and
- Spent Fuel Reprocessing (17).

Each paper is accompanied by an abstract in English.

Proposal Abstract D21(A79)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Imai, R. "Non-proliferation: A Japanese Point of View". Survival 25, no.1 (January/February 1979): 50-56.

4. **Summary:**

Unless safeguards are effective no arrangement (eg. international fuel banks or multinational reprocessing) can meet basic non-proliferation objectives because the international community would have no tool to detect and deter violations. Safeguards conceived of as a technical fix based only on careful accounting of nuclear material have been found ineffective in certain cases. Specifically, such a safeguards system cannot deal with large bulk material handling facilities like reprocessing plants or with "abrupt diversion" in which a large quantity of weapons-usable material is diverted within a very short time.

The present safeguards system was never intended to handle unlikely scenarios and to catch diverters red-handed; rather it was conceived as a means to deter states from engaging in weapons-oriented nuclear activities.

Imai suggests that an effective international safeguards system should include the following characteristics:

(1) Safeguards should apply to the entire fuel cycle within a state and should employ not only material accountancy control but also advanced technologies to detect the physical removal of nuclear material from facilities as well as computerized checks on the material flow to detect anomalies within the national fuel cycle. It should be based on the multiple application of safeguard measures based on different principles which will raise the level of operational confidence of the deterrence system.

(2) The system should employ technical means to extend the "critical time" for nuclear materials so that diversion will become more time-consuming and costly.

(3) Rather than trying to prevent diversion, the system should look for indications of weapons-oriented anomalies within the peaceful fuel cycle. The existence of secret plutonium handling or uranium-enrichment plants or unexplained refusals to accept inspections should be considered more serious than excessive "material unaccounted for".

(4) The safeguards system should be directly and promptly connected with some international arrangement for making political judgements on reports of anomalies and for imposing sanctions.

(5) The way safeguards apply should differ between states accepting full fuel cycle coverage and offering important national control and protection structures, and those which do not.

Proposal Abstract D22(A79)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Kapur, Ashok. International Nuclear Proliferation: Multilateral Diplomacy and Regional Aspects. New York: Praeger, 1979.
   See also: - International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (see abstract D12(I72)).

4. **Summary:**

This study of nuclear proliferation examines how national perceptions of the international environment influence national decisions about nuclear power. Chapter 5 (pp.120-133) covers the problems of nuclear safeguards. Specifically, Kapur reports on the work of the Standing Advisory Group on Safeguards Implementation (SAGSI) which was established in 1975 to provide advice to the director-general of the IAEA.* SAGSI's work reflects dissatisfaction with the safeguards system established by INFCIRC/153. On the technical level, there is criticism of the material accountancy approach, but SAGSI also attempts to address all the facets of the system, including political dimensions.

The original safeguards system devised in 1971 did not foresee the addition of reprocessing and plutonium fabrication facilities to national fuel cycles. With this development, the uncertainties of the material accountancy approach become significant. SAGSI focussed on the concept of "critical time", that is, the time required to make a bomb, and recommended that safeguards should be designed to detect the diversion of nuclear materials within the time required to make a bomb. It is thus necessary to apply different safeguards systems to plants of different sizes which use different production processes. Safeguards should be designed on a facility-by-facility basis, rather than applied using a single model generated from abstractions.

In the new approach, containment and surveillance techniques take on greater importance. The IAEA must also play a greater role in implementing safeguards because reliance on state systems of accounting for and control of nuclear materials will be reduced somewhat.

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* Members include experts from Canada, Japan, Mexico, France, the United Kingdom, India, the United States, the USSR and the German Democratic Republic.

Proposal Abstract D23(A80)

1. Arms Control Problem:
   Nuclear weapons - proliferation

2. Verification Type:
   On-site inspection - IAEA safeguards

3. Source:
   Fischer, D.A.V. "Safeguards Under the Non-Proliferation Treaty". Disarmament 3, no. 2 (July 1980): 35-41.

4. Summary:

Fischer states that the technical shortcomings of safeguards do not constitute an impediment to an effective international non-proliferation regime. Obstacles which exist are political rather than technical in nature. The application of safeguards to the common light-water reactor "is a relatively simple matter" (p. 38). One third of the fuel bundles in these reactors are replaced annually, but the possibilities for diverting nuclear material are minimal. In between fuel core changes, verification at three-monthly intervals can confirm that there has been no unreported removal of spent fuel from the storage facility or from the reactor itself. The IAEA installed tamper-resistant cameras and video-recorders which take half-hourly pictures of the sensitive parts of the plant. Inspectors check these pictures every three months. The IAEA is also developing sensors to record all movements of material, transportable counters which can determine the quantity of plutonium in a fuel rod on the site itself, methods for counting the number of fuel bundles moving through the fuel cycle and other analytical instruments. These developments may reduce the need for manpower in verification.

The IAEA has established an international group to develop arrangements for placing separated plutonium in IAEA custody with the consent of the states concerned. The plutonium would be released in accordance with rules and principle agreed to by involved countries. The IAEA Statute provides for this safeguard measure, but it has not been acted upon until recently.

NPT Safeguards are currently applied in more than 86 per cent of the nuclear plants in all the non-nuclear states and more than 11 per cent of plants are covered by safeguards outside the framework of the Treaty. In order to expand the regime, Fischer argues, the IAEA must expand its resources in order to fully apply effective safeguards to existing plants and to assist the development of nuclear energy in countries which are parties to the NPT.

D24(A80)

Proposal Abstract D24(A80)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspections - IAEA safeguards

3. **Source:**
   Imber, Mark F. "NPT Safeguards: The Limits of Credibility". Arms Control 1, no. 2 (September 1980): 177-198.

4. **Summary:**

The author critically evaluates the NPT (INFCIRC/153) safeguards regime according to five "common-sense" criteria:

(1) whether the safeguards system applies common rules and procedures to all states,
(2) whether the system applies to all aspects of the nuclear fuel cycle in each state,
(3) the technical rigour of the system,
(4) the credibility of sanctions, and
(5) provisions for review and amendment.

After reviewing in detail the INFCIRC/153 system on each of these criteria the author concludes that there are several inadequacies in the system. The most significant of these are:

(1) The permissive exception of the EURATOM-IAEA Safeguards Agreement is unfortunate in the context of the first criterion.
(2) Regarding the second criterion, the exemption of non-proscribed military uses and mining and ore processing are problem areas.
(3) Regarding the third criterion, the rigour of the system is weakened by limits to material accountancy accuracy relative to volume of materials subject to safeguards. This is compounded by limits placed on the timeliness of detecting diversion and upon the activities of inspectors.
(4) The sanctions available to the Agency are entirely inadequate.
(5) The lack of provisions for renegotiating Safeguards Agreements hinder improvements to the rigour of the system.

Proposal Abstract D25(A80)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices
   - seals

3. **Source:**
   Leutters, F.O. Containment and Surveillance Equipment Compendium. Alberquerque, New Mexico: Sandia Laboratories, February 1980.

4. **Summary:**

This is a compendium of the hardware used by the IAEA for the purposes of containment and surveillance. It is a highly detailed document which contains an exhaustive survey of equipment currently in existence or being developed.

Containment refers to the emplacement of "physical barriers...which contain or restrict the movement of nuclear materials", while surveillance is "direct or instrumented observation to detect or indicate the movement of nuclear material" (p.12). Together, containment and surveillance equipment serve to "detect and record the occurrence of specific activities or situations" (p. 13). This means that activities within nuclear processing plants will be monitored by various means to ensure that nuclear material is not diverted to other uses. This central purpose may then be divided into three separate tasks. First, the IAEA must maintain 'sample integrity' by ensuring that no tampering or duplication has occurred prior to on-site inspections. Changes in stock inventory of nuclear materials should also be monitored by surveillance equipment, so that frequent on-site inspections are not required for minor fluctuations in inventory. Finally, containment and surveillance equipment will be used to detect and monitor any diversion of nuclear materials at all times.

Seals: Seals are used for the containment of nuclear material and to prevent unauthorized entry through sealed openings. They may impede entry to some extent, but are intended primarily to ensure that any such entry would be detected. A system which uses seals consists of: (1) the seals themselves, (2) techniques and devices for the storage, application, removal and identification of seals, and (3) the selection and inspection of the site to be sealed. The whole system must be tamper-proof in order for the seal to be effective. For example, the hinges on the door to be sealed must be as secure as the seal itself. Special precautions must also be taken to ensure that a supply of spare seals is not accessible. Otherwise, a seal may be

broken and subsequently replaced, so that an unauthorized entry would remain undetected. This substitution of seals may be prevented, however, through the use of 'fingerprinted' seals which presumably have their own unique design that permits identification. The use of seals will be greatly assisted by thorough and effective on-site verification, as such inspections will detect whether a seal has been tampered with. By itself the seal is not an absolute guarantee that nuclear material will remain inaccessible, but they do help to monitor its storage and movement. The various kinds of seals used are described along with details regarding their manufacture and development.

Cup and Wire Seal: The cup and wire seal consists of three metal stampings and a wire which form a sealed cavity attached by wire to the item to be sealed.

Label Seal: A label seal is a piece of vinyl or paper which is attached by adhesive to two adjacent surfaces to ensure that neither has been moved. They are distinctively marked with a 'signature' to prevent a label from being removed and then replaced.

General Purpose Ultrasonic Seal: This seal consists of two metal or plastic parts joined by a steel snap ring. A wire is threaded through the item to be sealed, and then the two parts snap together, forming a cavity over the wire juncture.

Fibre Optic Seal System: This seal verifies long term containment, and consists of a fibre optic seal, a seal-assembly tool, a hand-held microscope and a photomicrographic camera. The fibres are formed in a loop and captured in a plastic housing around the item to be sealed. The fibres intersect randomly and are photographed. A later photomicrograph is then compared with this original photomicrograph to ensure that the seal has not been tampered with.

Electronic Seals: These seals also capture a fibre optic bundle in a loop, but the fibres are contained in an electronic housing rather than plastic. The integrity of the seal is then verified by a computer programmed verifier unit which displays a unique sequence of numbers and letters.

Optical Surveillance Systems: These systems provide "a visual record of the movement of nuclear material or the integrity of containment" (p. 37). They can monitor many kinds of activities, providing both basic information on plant activity and data which supplements other surveillance systems. There are two modes of optical surveillance systems which differ in the retrieval and processing of data.

Film Systems: Film systems use photographic equipment with a timing device which is housed in a tamper-proof casing. These cameras must be serviced to retrieve the data recorded on film. While this method is cost-effective, its capabilities are limited by the amount of film, the delay in processing and lack of control over the timing of surveillance. In addition, photographic images are often affected by environmental factors such as the amount of light or high levels of radiation.

Television Surveillance: This surveillance system relies on closed circuit television cameras which are connected to a control console by cable. Video recorders are used to store data, and a triggering device is also required. Television surveillance may overcome many of the limitations that plague film systems, as they can relay data immediately and provide around-the-clock surveillance. Television cameras are also less susceptible to environmental factors. These optical surveillance systems have their disadvantages however, as they are more expensive, require more maintenance, are bulky, and produce an enormous amount of data to be processed.

Monitors: This refers to any instruments other than optical systems "which observe, regulate, or keep track of processes or operations involving nuclear materials" (p. 81). Three different kinds of monitors are described. Passage and flow monitors watch the passage of nuclear material through corridors, channels, pipes, etc., and look for abnormal flows which might indicate that material is being diverted. Integral presence indicators check the level of nuclear materials. Finally, activity monitors watch the motion or loading of equipment as a means of recording the movement of nuclear materials - this means that motors, forklifts or cranes might be monitored to detect changes in the size or weight of a load. All of these monitors can operate unattended for long periods of time, and are usually quite tamper-resistant. The optimal monitor will be completely tamper-proof, cheap, safe, and easily installed and serviced. It should also be able to operate under all conditions and provide clear, unambiguous information. While no monitor can fulfill all of these requirements, they may be tailored to specific tasks by 'trading off' some capabilities for others.

 D26(I80)

Proposal Abstract D26(I80)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. "Guidelines for states' systems of accounting for and control of nuclear materials". IAEA/SG/INF/2, 1980.
   See also: - "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)). INFCIRC/66/Rev.2, 16 September 1968 (abstract D10(I68)).
   - "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (abstract D12(I72)).

4. **Summary:**

This document provides a detailed set of guidelines for the establishment and operation of a State System of Accounting for and Control of Nuclear Material (SSAC) in order to meet obligations arising from safeguards agreements (INFCIRC/66 establishing non-NPT safeguards and INFCIRC/153 establishing NPT safeguards) concluded with the IAEA.

The main feature of the SSAC is a designated nuclear material accounting and control Authority (the "Authority") which is responsible for (Section 2.1):

(1) Establishing or helping to establish provisions governing the possession, transfer and use of nuclear material;
(2) Ensuring that the state's nuclear material accounting and control objectives are met;
(3) Serving as the liaison with the IAEA during the implementation of safeguards agreements;
(4) Developing, approving and implementing nuclear material accounting and control procedures; and
(5) Notifying government authorities if the loss, unauthorized use or removal of nuclear material is discovered.

More specific responsibilities of the Authority in meeting the requirements of accounting for and control of nuclear material include:

(1) Determining the starting point in the nuclear fuel cycle, the termination and exemption of accounting and control (Section 2.4.1);
(2) Categorizing nuclear material according to isotopic composition and irradiation level (Section 2.4.2);

(3) Establishing the factors to be taken into account in determining material balance areas (MBAs) including the existence and location of key measurement points, containment and surveillance possibilities (Section 2.4.3);
(4) Establishing the requirements for accounting and operating records and reports for each MBA (Section 2.4.4), for the measurement system (Section 2.4.5), for accounting and control of nuclear material flows (Section 2.4.6), for physical inventory taking by facility operators (Section 2.4.7), for identifying, reviewing, resolving and evaluating differences in all shipper/receiver measurements (Section 2.4.8), for striking material balances and for calculating materials unaccounted for (Section 2.4.9);
(5) Implementing the measurement control system and containment and surveillance measures (Sections 2.4.10 and 2.4.11); and
(6) Establishing the requirements for international transfers of nuclear material.

The establishment and operation of the above elements is covered in Section 3.3.

The document provides the general outlines of the inspection activities of the Authority. The Authority determines whether each potential licenced facility is capable of performing the required accounting and control functions and conducts periodic inspections to determine whether implementation meets the standard set by the Authority (Section 2.5.2). In this regard, possible inspection methods include:

(1) Examination of records from laboratory work and inventories;
(2) Observation of physical inventory taking and of operators' measurements;
(3) Independent measurements to evaluate the operators' measurements; and
(4) Checking seals and other containment and surveillance equipment.

The Authority should pay particular attention to independent verification and evaluation of operators' reports (Section 2.5.3).

The Authority should establish an information system which gathers the following information (Section 2.3):

(1) A list of current facilities with details on material accounting and control procedures including containment and surveillance;
(2) Data on nuclear material inventories;
(3) Data on transfers; and
(4) A record of inspection data and all operational information.

Section 3.5 provides an illustration of the practical application of the guidelines to reactors and storage areas containing small quantities of nuclear material.

The document also recommends that each state should make and regularly review laws and regulations to ensure that facilities and activities within its jurisdiction comply with the obligations created by the safeguards agreements (Section 2.2). These measures should govern nuclear material, facilities and international transfers.

Proposal Abstract D27(I80)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Nuclear Fuel Cycle Evaluation. INFCE Summary Volume. Vienna: published by the International Atomic Energy Agency, 1980. STI/PUB/534.

4. **Summary:**

The reports of the eight INFCE Working Groups include a great deal which is relevant to the verification of non-proliferation undertakings. Much, however, relates to measures that are intended to improve control of nuclear materials and technology which will thereby indirectly facilitate verification.

The reports identify those points in nuclear fuel cycles which are sensitive to the danger of diversion of materials and equipment to weapons related purposes. These points are:

(1) fresh fuel containing enriched uranium or plutonium,
(2) uranium enrichment,
(3) reactors,
(4) spent fuel storage,
(5) reprocessing, including plutonium storage and mixed oxide fuel fabrication, and
(6) spent fuel or waste disposal.

The summary volume and the reports of the Working Groups provide a detailed assessment of the dangers of proliferation for each of these points.

Three means of minimizing the danger of proliferation are identified by the INFCE. The first of these are technical measures which have a powerful influence on reducing the risk of theft but only a limited influence on reducing the risk of state level proliferation. Four categories of technical measures are specified:

(1) measures to reduce the presence of weapons-usable materials in separated form in the fuel cycle,
(2) measures to use radioactivity to protect those materials from diversion,
(3) measures to protect them by the use of physical barriers, and
(4) the use of lower enrichment levels for research reactor fuels.

If successful in reducing the number of routes to theft or diversion of materials, such technical measures should facilitate verification by enabling verification bodies to concentrate their efforts elsewhere.

Potentially more important than technical measures for reducing proliferation dangers are institutional measures. These include "a range of undertakings by either governments or private entities to facilitate the efficient and secure functioning of the nuclear fuel cycle and encompassing commercial contracts, intergovernmental arrangements, technical assistance programmes, international studies, non-proliferation agreements, supply assurances and international and multinational institutions" (p. 44). The purpose of these arrangements is to support and strengthen existing mechanisms of cooperation in peaceful use of atomic energy, the non-proliferation regime and the IAEA. Like technical measures these institutional measures are likely to facilitate verification by reducing the burden on verification organizations.

The third means of reducing proliferation dangers are improved safeguards, which relate directly to verification. The summary report describes briefly the existing international safeguards regime of the IAEA. While the Working Groups in their reports did not identify significant problems with the methods applied to existing plants, further improvement to existing techniques was foreseen as necessary to meet safeguards objectives at reasonable costs in connection with technologies for uranium enrichment, industrial-scale reprocessing to irradiated fuel and mixed oxide fuel fabrication, all of which involve the possibility of access to special nuclear material in a form usable for nuclear weapons. Such improvement should include:

(1) taking into account the needs of safeguards when designing facilities,
(2) enhanced containment and surveillance, and
(3) improved methods of materials accountancy.

The INFCE concluded that effective international safeguards are essential to the nuclear power industry and the additional effort involved in safeguards is of importance. The summary volume and the reports of the Working Groups give a more detailed assessment of safeguards needs in relation to the points of the nuclear fuel cycle which are specified as sensitive to proliferation.

 D28(A81)

Proposal Abstract D28(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   dell'Acqua, F. et al. "The Development and Function of the IAEA's Safeguards Information System". IAEA Bulletin 23, no. 4 (December 1981): 21-25

4. **Summary:**
   This article describes the IAEA's computer based safeguards information system. The system allows two types of analysis and evaluation. In the first type, computer programs help inspectors to plan inspections by calculating the statistical intervals at which samples should be taken and evaluating the probability of detecting missing material using a variety of assumptions. The Agency keeps an inspection evaluation file for each major facility which contains data on material balances and methods of measurement which are updated after facility records are checked and inventories are verified. The second type of evaluation involves an assessment of verification measurements made in the field using weight, volume and non-destructive assay equipment. The computer compares the inspector's data with the facility operator's measurements and calculates measurement errors and acceptance criteria for significant differences. Most of the evaluation is currently done at IAEA headquarters, but the Agency is developing portable calculators for use in the field and at regional offices. The information system uses a commercially available database management system. The results of the computer evaluations are compiled in the Inspection Report and in Statements to Member States which are later summarized in the annual Safeguards Implementation Report issued by the IAEA.

Proposal Abstract D29(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices - recover

3. **Source:**
   Gallini, Linda D. "Nuclear Weapons Monitoring". <u>IEEE Spectrum</u> (July 1981): 48-55.

4. **Summary:**

This article discusses the importance of halting the proliferation of nuclear weapons in countries which currently do not possess a nuclear capability. Existing agreements are examined and some consideration is given to measures which might prevent such proliferation. Nations seeking a nuclear weapons capability may do so by a number of means: they may opt for dedicated development, diversion of nuclear material, acquisition through purchase or gift, or theft. This article focusses on the dangers of diversion of peaceful nuclear power towards weapons production.

International verification is identified as a 'key element' in arms control efforts directed towards the prevention of nuclear proliferation. The International Atomic Energy Agency (IAEA) safeguards system seeks to ensure that peaceful nuclear energy programs remain peaceful, and requires that information be provided on the "locations, quantities, form and movements of nuclear materials" (p.52). These measures seek to detect, rather than prevent the diversion of nuclear material for military purposes, so that verification measures need only detect the diversion of 'significant quantities' of nuclear material. Some states with a nuclear capability have refused to accept these safeguards, but efforts are being made to halt nuclear exports to countries which do not comply with IAEA standards.

Efforts are also being made to improve the effectiveness of these safeguards with the use of remote monitoring devices. The devices are part of an automated system emplaced at numerous nuclear sites which are then monitored from a central location. A remote monitoring system known as RECOVER is now being tested as part of the IAEA's efforts to develop improved safeguards for all nuclear facilities, and especially those for nuclear enrichment and reprocessing.

Proposal Abstract D30(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Gruemm, H. "Safeguards and Tamuz: Setting the Record Straight". IAEA Bulletin 23, no.4 (December 1981): 10-14.

4. **Summary:**

This article provides a case study of the planning and implementation of nuclear safeguards. The subject is the controversial Iraqi Tamuz research reactor which was attacked by Israeli planes on 7 June 1981. The Iraqis were allegedly using the reactor to begin work on a nuclear weapons programme.

Two main diversion strategies were anticipated in the safeguards planning phase. The first was the diversion of highly enriched uranium contained in standard fuel elements. The second was the undeclared production of plutonium. In response to the first possibility, IAEA inspectors were present at the reactor in June 1980 when the first fuel arrived. They counted, identified and determined the actual uranium enrichment of fuel elements. Two to three inspections per year were scheduled to be performed until more fuel elements were delivered from France. Then there would be an inspection every two to three weeks since more than one significant quantity of highly enriched uranium (one significant quantity is the amount of material needed to make a bomb) would be present. Diversion could not have occurred at Tamuz because the removal of most of the fuel elements would have shut down the reactor. Gruemm notes that "it is completely out of the question that such an overt act of diversion, which would have made it impossible for the reactor to operate, could have escaped the attention of the Agency's inspectors" (p.12).

With regard to the second diversion possibility, the Agency calculated that the reactor could produce about one or two significant quantities of uranium per year, but this would require a high fuel throughput of several cores per year. This would have been detected by Agency inspections and scutiny of information that France is committed to supply in advance. Modifications of the reactor necessary to produce plutonium would have been detected by visual inspection by both inspectors and automatic surveillance cameras. Gruemm concludes that "due to the transparent design of the reactor and clear visibility of all substantial changes of its configuration, diversion according to either strategy would have been quickly detected" (p.13).

Inspections were carried out on 28-29 June 1980 at the time of the arrival of the fuel assemblies in Iraq and on 18-19 January 1981 after an air attack on the research centre. Inspectors visited the research centre after the 18 June 1981 Israeli attack, but extensive destruction prevented access to the Tamuz building. Access was possible, however, after 9 November and two inspectors, G. Rabot of France and V. Seleznev of the USSR, conducted an inspection. The presence of all fuel assemblies in their original condition was verified by all inspections so that non-diversion was confirmed.

Proposal Abstract D31(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring
   - seals

3. **Source:**
   Klik, F. "Field Experience of Safeguards Inspectors". IAEA Bulletin 23, no.4 (December 1981): 15-20.

4. **Summary:**

The IAEA has extensive experience in safeguarding some types of facilities, but only limited experience with others. Among the former are thermal power reactors, particularly light-water reactors, and conversion and fuel fabrication plants connected with bulk-handling facilities. In the latter category are fast-breeder reactors and their support facilities, as well as reprocessing and enrichment plants. A key component of the safeguards system is nuclear materials accountancy, but many inspectors have little or no experience in auditing records and reports. IAEA experience with auditing should enable it to train inspectors better in auditing.

Equipment used by inspectors for non-destructive assay (NDA) has included a portable, two-channel gamma spectrometer (the SAM-II) to confirm the presence of uranium and measure its enrichment. A newer instrument, the Silena, has greater precision and accuracy because of its 1,024 channels and its readings can be recorded directly onto a cassette tape, but inspectors have to be more highly trained to take full advantage of the instrument. The SAM-II cannot verify plutonium acceptably and even the Silena requires a High-Level Neutron Coincidence Counter in order to verify plutonium from fast-reactor fuel assemblies. However, the latter procedure has proven to be quite successful.

IAEA inspections of important facilities now involve a team of inspectors working for several days or a week, whereas they formerly consisted of a single inspector working for one day with a SAM-II. Attracting, training and motivating a team of inspectors is therefore a new challenge for the IAEA.

Other verification instruments used by inspectors are:

- night-viewing devices to observe the Cerenkov glow emitted by irradiated fuel;
- seals on containment facilities (the Agency currently applies and detaches over 3,000 seals per year and its computer records contain the history of more than 10,000 seals); and
- camera and TV surveillance (six million pictures were taken and evaluated in 1980).

 D32(A81)

Proposal Abstract D32(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Pontes, B., G. Bates and G. Dixon. "Training the Agency's Inspectors". IAEA Bulletin 23, no.4 (December 1981): 26-29.

4. **Summary:**
   IAEA inspectors are trained by a Training Unit of the Agency and by member states in support programs. Over a period of six months new inspectors attend an eight week introductory course full time and then a two week course after they have performed a few inspections. After completing basic courses, the inspector can upgrade his skills in two advanced courses and become an experienced inspector. Advanced courses are also available in the second year of the inspector's initial contract. In training programs sponsored by member states, the entire cost of the training is paid by the sponsoring government. This is an important way of supplementing the Agency's limited safeguards budget.

Proposal Abstract D33(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices - RECOVER

3. **Source:**
   Prokoski, Francine. "A Watchdog for Nuclear Development: Technology Can Help Monitor Civilian Uses of Nuclear Energy While Discouraging Military Applications". IEEE Spectrum (July 1981): 51-55.

4. **Summary:**

This article describes International Atomic Energy Agency (IAEA) safeguards which prevent the diversion of nuclear materials to military uses. The IAEA's primary safeguards rely on materials accountancy and require that nuclear facilities provide records, account for the use of all materials, and permit periodic international inspection to make independent measurements and observations. These safeguards seek to detect a number of evasive tactics such as the over-statement of materials removed from facilities, the falsification of records and reports, the use of accountability uncertainties, and the understatement of receipts on production.

Some secondary measures are directed towards containment and surveillance. Film and video surveillance both record activities in nuclear plants, while the placement of seals on storage tanks prevents unauthorized access to nuclear materials. Some other remote sensors which record movements and activities within the plant include load/position indicators, fuel assembly counters, reactor power monitors, radiation passage monitors, and portal monitors. A more complex remote monitoring system which is currently being developed is the RECOVER system (remote continuous verification). This system may help to offset higher costs, greater demands for manpower and more extensive supervision. It transmits information on activities within the plant and provides secure communication of data from the facility to IAEA headquarters. Originally designed to 'diagnose the performance' of sensing devices, the RECOVER system will enhance the reliability of such devices while reducing the need for personnel to maintain them and conduct on-site inspections. It is stated that "RECOVER would not replace manual inspections; rather, it could help make such inspections more efficient" (p.53).

RECOVER collects, stores and transmits data from a nuclear facility to IAEA headquarters through a complex array of modular

components. Basically, these consist of a multiplexer which compiles and maintains all current data on sensors, and a modem through which this data is transferred over telephone lines from the facility to the control console at IAEA headquarters. All data transfers are encrypted for security and accuracy. The system is modular so that sensors and sites may be added to the system, and each multiplexer can support 30 monitor units. All data is recorded and stored at the control centre, but it is also suggested that each of these on-site multiplexers be 'interrogated' once a week on a random schedule.

On the basis of this evidence, it is concluded that the RECOVER system "appears to offer a significant technique for enhancing the effectiveness of international nuclear safeguards" (p.55). The system has the added advantage of improving IAEA safeguards at a reasonable cost.

Proposal Abstract D34(A81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices - RECOVER

3. **Source:**
   von Baeckmann, A. "The Application of Modern Methods and Techniques in Safeguards Operations". IAEA Bulletin 23, no.1 (March 1981): 15-19.

4. **Summary:**

This article describes the application of modern measurement and containment/surveillance techniques to IAEA safeguards operations. Chemical analysis in laboratories provides most of the IAEA's quantitative information on safeguarded material. This method is highly accurate, but is costly and slow. Since samples have to be transported, the results are usually available only after 3-5 weeks. In contrast, non-destructive analyses provide results immediately but with less accuracy.

Non-destructive assay (NDA) techniques are used to check the type and quantity of nuclear material in containers which cannot be sampled without destroying the integrity of the container. In the most commonly used NDA techniques, measurements are based on the interaction of radiation with the material of the detector. Information is processed in advanced analysers and recorded on magnetic tape. The information is then stored in the Agency's central computer. High-level neutron coincidence counters are used to determine quantities of nuclear material, particularly of plutonium. This system has yielded calculations that agree to better than 2% with the production data for certain materials. The fuel content of a research reactor core can be verified by measuring the Cerenkov glow in a swimming pool storage area. The intense glow indicates that the reactor is operating and must therefore contain the minimum critical quantity of nuclear fuel. This is often sufficient proof that nuclear material required to produce an explosive nuclear device has not been diverted. Although the Cerenkov glow fades significantly after the reactor has been shut down, special light intensifiers and night vision devices can permit observation and photography of the glow even after a period of ten years. This technique is used to verify the irradiated character of spent fuel in storage. New instruments may allow semi-quantitative measurements using this technique. Used individually, non-destructive assay techniques cannot easily verify nuclear materials, but, when used in combination and calibrated together, they provide a useful verification system.

Containment and surveillance measures are employed to avoid unnecessary and expensive remeasurement of nuclear materials enclosed in containment facilities. Metallic seals are used to verify the integrity of containers, but they cannot be checked on the spot. Ultrasonically _in situ_ verifiable seals, fiber optic seals and electronic seals are being developed to solve this problem.

The Agency uses cameras operating in a time lapse mode to survey movements of fuel. The standard double camera system has a capacity for 100 days of operation with 3 frames taken per hour. However, in high humidity, the film is prone to jamming. Improvements of the system will double its capacity, annotate date and time on each frame, compensate for varying light conditions, improve tamper resistance and increase reliability. Closed circuit television systems are used when continuous surveillance is required, when radiation levels would damage the film, or when the recording has to be reviewed on the spot. Twelve of these units are operating in IAEA safeguarded facilities. Microprocessor controlled systems currently being evaluated may increase the reliability of the television systems.

Reviewing all of the pictures is a time consuming process so a special semi-automatic Super 8 mm film scanner has been used to detect motion which then can be more carefully reviewed. Another technique to improve reliability is also being evaluated: the RECOVER (Remote Continual Verification) system is connected directly to containment/surveillance devices and produces an alarm at IAEA headquarters if abnormal data is detected. IAEA inspectors could then examine the site (see abstract D45(G83)). The system is being tested in a number of countries.

Proposal Abstract D35(I81)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. "IAEA safeguards: an introduction". IAEA/SG/INF/3, 1981.
   See also: - "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev. 1, June 1972 (abstract D12(I72)).

4. **Summary:**

This document reviews the evolution of the IAEA safeguards system and its objectives, and provides a detailed description of the system itself. The system consists of three distinct stages:

(1) The examination of information provided by the state concerning:
   - design information on installations under safeguards;
   - accounting reports containing nuclear material inventories, receipts and shipments;
   - documents which clarify reports; and
   - advance notification of international transfers;

(2) The collection of information by the IAEA through inspections; and

(3) The evaluation of the information by the IAEA.

Nuclear materials accountancy is used to determine the quantities of nuclear material present in a specific area and the changes in these quantities over a certain period of time. The difference between the book inventory and the actual physical inventory, "materials unaccounted for", is calculated and evaluated and a statement is prepared. Figure 8 (p. 22) graphically represents the materials accountancy process. IAEA inspectors use several methods to independently verify the accounting. These methods include comparison of records and reports, item counting, item identification, non-destructive assay measurements and chemical analysis of samples (see figure 9, p. 23).

Containment/surveillance measures may use the application of tamper-detecting seals. Surveillance involves observation by humans and instruments such as cameras to detect undeclared transfers of nuclear material, tampering with containment or safeguards devices and the submission of false information. Figure 11 illustrates a combined application of containment and surveillance in which spent fuel is contained by the walls of a building and surveillance is provided by twin cameras taking pictures at intervals shorter than the time needed to remove any fuel.

The NPT safeguards system (INFCIRC/153) distinguishes between three types of inspections: routine, ad hoc and special. These inspections carried out by IAEA inspectors serve to:

(1) Examine relevant records;

(2) Make independent measurements of safeguarded nuclear material;

(3) Ensure that equipment is calibrated and functioning properly;

(4) Obtain samples for analysis; and

(5) Affix, inspect and remove IAEA seals.

The document also briefly discusses the administrative structure of the IAEA safeguards systems and its operations in regional sections.

The IAEA estimates that the cost of safeguards "is not large - of the order of the cost of a single military aircraft per year" (p. 37).

Proposal Abstract D36(A82)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Herron, L.W. "A Lawyer's View of Safeguards and Non- Proliferation". IAEA Bulletin 24, no.3 (September 1982): 32-38.
   See also: - International Atomic Energy Agency. "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev.2, 16 September 1968 (abstract D10(I68)).
   - International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (abstract D12(I72)).

4. **Summary:**

The author comments on a number of aspects of the IAEA's safeguards system. He remarks that, even with less than perfect detection, the safeguards system can deter the diversion of safeguarded nuclear material to non-peaceful use by making the consequences of detection politically unacceptable.

Effective procedures for safeguarding material in large bulk-flow facilities are needed and are currently being developed. However, policy-makers and technicians may not be paying adequate attention to safeguarding the emergent technology of laser-stripping. This technique apparently has the potential for "back-room" enrichment and reprocessing and gives new significance to stocks of depleted uranium which are currently not subject to IAEA inspection.

The Agency should develop an up-to-date version of INFCIRC/66 and seek to have it approved by the Board of Governors. The current document is more than fourteen years old. In addition to existing provisions, new provisions should cover: containment and surveillance techniques, safeguards on subsequent generations of nuclear material, technology transfers and heavy water, and continuing safeguards requirements even after the termination of the safeguards agreement.

Some critics of the safeguards system suggest that the Agency gives too much advance notice of inspections, but Herron contends that "the legal prescriptions appear to strike a reasonable balance between ideal inspection needs on the Agency's side, and the legitimate self-interest of states in minimizing inconvenience and undue interference in plant operation" (p.35).

Herron suggests that under INFCIRC/153 agreements, the Agency has some rights with respect to undeclared nuclear materials or facilities and, in some cases, involving safeguarded nuclear material transferred to facilities covered by INFCIRC/66 agreements, it may also have some rights under INFCIRC/66 agreements. This means that if the Agency suspects that a state has not declared some nuclear material, the Agency can question the state and request special inspections which may give it access to locations other than the specified strategic points open to it during routine inspections.

The main task of NPT safeguards is to provide assurance of non-diversion of nuclear material, therefore, criticism that the Agency would not be able to provide 'timely warning' so that the international community could intervene to dissuade a potential nuclear weapon builder is unjustified. The only coercive measure available to the Agency is publicity in a case of noncompliance. After that, the Security Council and General Assembly of the United Nations may invoke sanctions under the UN Charter.

Proposal Abstract D37(A82)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Muntzing, L. Manning. "Safeguards and Nuclear Safety: A Personal Perspective". IAEA Bulletin 24, no. 4 (December 1982): 7-10.

4. **Summary:**
Despite the generally effective functioning of the IAEA safeguards system, the system could be strengthened. Increases in the safeguards budget could allow the Agency to remedy the problem of manpower and equipment shortages. There must also be reform of the provision which allows a host nation to veto Agency inspectors on grounds of nationality. A suitable reform could be to allow each country a number of "pre-emptory challenges" after which the nation would have to "show cause" for rejecting any inspector nominated by the Agency. There should be a training academy for IAEA inspectors to develop their knowledge of safeguards techniques and equipment. The equipment itself should be further developed and supported by a maintenance and repair infrastructure. Reliable sources for spare parts are needed. Redundancy of cameras and other surveillance equipment would give the system greater reliability and integrity. Before these improvements can occur, however, political constraints on increasing the safeguards budget must be overcome. A possible solution could be to impose "user fees" for IAEA safeguards services based on the thermal output of safeguarded reactors. Even with an improved safeguards system, the fees for a 1000-megawatt reactor would not be more than a few hundred thousand dollars a year.

 D38(A82)

Proposal Abstract D38(A82)

1. **Arms Control Problem:**
   (a) Nuclear weapons - proliferation
   - comprehensive test ban
   (b) Any arms control agreement

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices - RECOVER

3. **Source:**
   Pieragostini, Karl. "Recovering Verification". Arms Control Today (December 1982).

4. **Summary:**

This article looks at the implications of Remote Continuous Verification, the RECOVER program, for verifiable arms control. The Reagan Administration appears to be relatively disinterested in this program despite their professed concern for verification and the potential solution that this project offers. The system is designed to provide "remotely controlled on-site verification which will not require more intrusive inspection visits" (p.4).

The RECOVER system involves one or more cameras attached to a monitoring unit which transmits data to an on-site multiplexer. The data is then transmitted to a remote verification unit via existing global telecommunications. The data to be transmitted by RECOVER is currently limited to 'diagnostic and integrity data'; this means that it will monitor other IAEA sensors to ensure that they are not being tampered with.

The potential utility of this system is obvious, for it would provide important on-site data without requiring more intrusive measures of verification. It would permit the verification of a comprehensive test ban, could ensure that designated plants remain closed, and could also verify a warhead testing ban. It is concluded that, as a 'blueprint' for future verification measures, the RECOVER concept is of impressive significance given its potential effectiveness and acceptability to the Soviet Union.

Proposal Abstract D39(I82)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. Nuclear Safeguards Technology 1982. Proceedings of a Symposium held in Vienna from 8-12 November 1982. 2 volumes. STI/PUB/629.

4. **Summary:**

The papers from the symposium emphasize practical experience with working verification equipment and with authentication, "a new word implying that the inspector has valid reason to trust automatic measurement equipment installed and used by the plant operator" (see foreword). Near-real-time material accountancy, an advanced concept discussed in 1978 (see abstract D20(I78)), was discussed with regard to the practicalities of various statistical tests and with regard to handling its remaining practical problems.

The proceedings consist of 96 papers (85 English, 7 French and 4 Russian) divided into the following chapters:

Volume I - An Assessment of Existing Safeguards (5 papers),
- Approaches to Safeguards (7),
- State and Facility Material Control Systems (6),
- Destructive Analytical Measurements (6),
- Containment and Surveillance in IAEA Safeguards (16),
- Isotope Correlation Techniques (3), and
- Near-Real-Time Material Accountancy (5).

Volume II - Non-Destructive Measurements (26),
- Statistics in IAEA Safeguards (11),
- Safeguards for Reprocessing Facilities (5), and
- Safeguards for Enrichment Facilities (6).

Each paper is accompanied by an abstract in English.

Proposal Abstract D40(A83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation
   - fissionable material "cutoff"

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Blix, Hans. "Can International Safeguards Stop Nuclear Proliferation?" Disarmament 6, no. 3 (Autumn/Winter 1983): 1-7.

4. **Summary:**

The author reviews the contribution of IAEA safeguards to preventing horizontal nuclear proliferation and considers the possible application of safeguards to stemming vertical proliferation. With regard to horizontal proliferations so far, no diversion of materials has been identified, so the system has helped to build confidence. Between 1978 and 1983, the number of installations under safeguards increased from 560 to 840 and man-days of inspection rose from 2,260 in 1977 to 6,310 in 1982. The system is effective, but needs to be accepted by more states.

IAEA safeguards could possibly provide a model for verifying nuclear arms agreements. In particular, a complete halt or limitation of the production of nuclear materials for warheads could be verified using the techniques and experience of IAEA safeguards. Safeguards could also assist in verifying the transfer of fissionable material to storage facilities after the dismantling of some of the existing stocks of nuclear weapons. However, such procedures would require more resources than are currently available to the IAEA. Other considerations include:

(1) Safeguards are currently utilized only in installations producing for peaceful purposes.

(2) Safeguards are used in facilities identified by the host country. It is unlikely that states would accept inspectors moving around freely in search of unreported installations.

(3) Safeguards on peaceful nuclear installations have been accepted by four nuclear-weapon states and are being applied in the United States, the United Kingdom and France. Discussions with the USSR will address which of the Soviet installations will be open for IAEA inspection. China does not participate in the IAEA.

Proposal Abstract D41(A83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Gruemm, H. "Safeguards Verification - Its Credibility and the Diversion Hypothesis". IAEA Bulletin 25, no. 4 (December 1983): 27-29.

4. **Summary:**

The design of IAEA verification activities at nuclear facilities is based on the working hypothesis that diversion of nuclear material is possible and that a risk of low but non-zero probability exists in all application of safeguards. Diversion analysis identifies anomalies which may be indicators of acts of diversion. Most anomalies result from innocent causes such as measurement or reporting errors or equipment failure, but some could result from diversion of nuclear material. Diversion activities encompass: the unreported removal from or introduction into a nuclear facility of nuclear material, including material from a facility not covered by safeguards; the unreported alteration of the composition of nuclear material within the facility; and prohibited uses of nuclear material within the facility.

The diversion hypothesis also involves the possibility that a divertor might try to conceal anomalies created by diversion by falsifying reports, replacing missing material with material borrowed from other facilities, manipulating measurements or interfering with containment or with IAEA equipment. Another possibility the IAEA must cope with is the flow of nuclear material from unsafeguarded facilities since the IAEA has no verification procedures to confirm the accurate reporting of all nuclear material subject to safeguards (under INFCIRC/66/Rev.2 safeguards agreements (abstract D10(I68), unsafeguarded facilities may exist in a state). The existence of a hot cell complex not containing nuclear material (and therefore not under safeguards) which could be used to reprocess spent fuel after diversion cannot be ruled out. The diversion and stockpiling of spent fuel for prohibited use later must also be anticipated.

If the IAEA safeguards system properly accounts for all of the possibilities mentioned above, the overall probability of detection will increase. This will raise the level of assurance, a key indicator of safeguards effectiveness. The other indicator, scope of achievement, is the percentage of nuclear material/facilities under safeguards for which the inspection goals have been fully attained. This percentage has increased considerably over the years. The detection probability has also increased as a result of the use of more manpower and equipment and systematic evaluation methods.

Proposal Abstract D42(A83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Complaints procedures - referal to International Court of Justice

3. **Source:**
   Imber, Mark F. "Arms Control Verification: The Special Case of IAEA-NPT 'Special Inspections'". In The Verification of Arms Control Agreements, pp. 57-75. Edited by Ian Bellany and Coit D. Blacker. London: Frank Cass, 1983.
   See also: - International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972. (Abstract D12(I72)).
   - Imber, Mark F. "NPT Safeguards: The Limits of Credibility". Arms Control 1, no.2 (September 1980): 177-198. (Abstract D24(A80)).

4. **Summary:**
   This article discusses and evaluates the IAEA safeguards system for verifying adherence to the Non-Proliferation Treaty (NPT). The safeguards system involves verification by material accountancy and inspection. Evidence suggests that material accountancy by itself is inadequate to verify compliance, therefore the role of inspectors in confirming the accuracy of material accountancy has taken on considerable importance.

   The author reviews the three types of inspections permitted by the NPT safeguards regime - ad hoc, routine and special - which are differentiated by their frequency, scope and the purpose of activities involved. In practice, inspectors are limited in their role by restrictions on access imposed by states. A state may impose specific limitations upon the timing and scope of inspections if "unusual circumstances require extended limitations on access by the Agency" (INFCIRC/153 paragraph 76d), if the state considers that the inspection will unduly concentrate on specific facilities (INFCIRC/153, paragraph 82), or if the state wishes to delay the visit of an inspector for a good reason. The author recommends that paragraphs 76, 78, 79, 82 and 85 of INFCIRC/153 be amended to solve the problem of limited access for inspectors.

The author also notes that the Agency has no power to prevent violations or to seize materials or facilities. He suggests that, in order to improve the implementation of the safeguards system, the power to determine compliance with safeguards obligations should be transferred from the Board of Governors of the IAEA to the Inspector General of Safeguards or the Director General of the IAEA. This would reduce the possibility of political factors affecting the system. The author also recommends that recognition of compulsory jurisdiction of the International Court of Justice be included in future INFCIRC/153 agreements, in order to resolve allegations concerning breaches of safeguards.

In addition to verifying material accountancy with inspections, the Agency uses sampling and chemical analysis to monitor radiation from spent fuel rods. New techniques have improved the effectiveness of this operation. Other verification methods used by the Agency include seals on containment facilities and time-lapse still photography or closed-circuit television.

Despite the negative aspects mentioned above, the system has worked effectively and stands as "the most advanced variety of international arms control verification currently in operation". So far no suspected diversions have been reported and no sanction procedures have been publicly initiated.

PROPOSAL ABSTRACT D43(A83)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
On-site inspection - IAEA safeguards

3. **Source:**
Krass, Allan S. et al. Uranium Enrichment and Nuclear Weapon Proliferation. London: Taylor and Francis, 1983.
See also: - International Atomic Energy Agency. "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev.2, 16 September 1968 (abstract D10(I68)).
- International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev.1, June 1972 (abstract D12(I72)).

4. **Summary:**
Nuclear explosive material can be produced from either plutonium or enriched uranium, but beginning in the 1960s many countries invested in research and development of new techniques of uranium enrichment which could give them an indigenous enrichment capability. These new processes have made nuclear proliferation easier and the authors feel that "technical mechanisms for safeguarding enrichment facilities and for controlling exports of sensitive components and know-how are seriously inadequate" (p.xvi). Furthermore, there has been very little experience with applying IAEA safeguards to enrichment facilities. This book describes the uranium enrichment process and past efforts to control nuclear weapon proliferation with an emphasis on the role played by enrichment. The book does not cover plutonium production and its impact on proliferation. Chapter 3 (pp. 41-80) evaluates possible options for control and safeguarding of enrichment facilities.

The IAEA has only recently begun to design and implement safeguards systems for enrichment facilities. In fact, only three enrichment facilities are listed as being under IAEA safeguards (one in Japan and two pilot plants in the Netherlands). While details of these systems are secret, speculation suggests that the safeguards agreements would consist of either INFCIRC/153 or INFCIRC/66/Rev.2 provisions. This means that IAEA methods of nuclear material accountancy and containment and surveillance techniques would be used. The authors provide details of the application of these methods to enrichment facilities.

One problem which may arise is that nuclear material accountancy may provide large absolute uncertainties in important measurements at large enrichment facilities. As a result, "small diversions from large facilities will always be difficult to detect by pure accountancy techniques" (p.48). The IAEA ultimately relies on each state's nuclear materials accounting system and periodic routine inspections to verify the accounting.

Supplementary containment methods will probably not play much of a role in safeguarding enrichment facilities because a continuous flow of materials is necessary for plant operations. Facility operators would, therefore, resist the restrictions imposed by the containment of materials. However, sealing doors and exits and restricting access to the enrichment process area to a small number of entrances could allow minimally intrusive use of containment measures. Surveillance techniques using sealed television cameras, optical, acoustic and seismic sensors, as well as inspections, would be of great value, but economic and political constraints may limit their use. Furthermore, concern for protecting industrial secrets may exclude inspectors and surveillance equipment from certain key areas of enrichment facilities. The IAEA may attempt to compensate for this obstacle by using information on the design, layout and operations of a plant to infer what is occurring within a restricted area.

Placing all enrichment facilities under IAEA safeguards would substantially reduce the risk of nuclear proliferation, but this is not likely to occur. Various institutional mechanisms have been designed to control nuclear materials and prevent nuclear proliferation, which have some relevance for the control of enrichment facilities. The Nuclear Suppliers' Group Guidelines (see IAEA INFCIRC/254, February 1978, abstract M12(I78)) require IAEA safeguards to be applied to transferred nuclear material, equipment and facilities as well as to sensitive facilities for which the technology has been transferred. The transfer of enrichment facilities or technology is subject to a limitation of 20 per cent enrichment of uranium unless prior consent to further enrichment is obtained from the supplier nation. The US Nuclear Non-Proliferation Act of 1978 also requires full-scope IAEA safeguards in the recipient non-nuclear weapon countries.

 D44(A83)

Proposal Abstract D44(A83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Price, L. "Nuclear Safeguards - A New Profession?" Atom 326 (December 1983): 292.

4. **Summary:**
Price reports that the International Atomic Energy Agency aims to detect a quantity of nuclear material based on the fast critical mass of a reflected metal sphere (e.g. 8 kg of plutonium or 25 kg of uranium-235). The Agency works to achieve a confidence level of 95 percent. The frequency of verification depends on the "diversion risk" and varies from every three weeks for plutonium to once a year for irradiated fuel. Non-destructive assay in accordance with a statistical sampling plan is used to physically measure samples after nuclear material accountancy has been verified. Non-destructive assay for uranium identifies the unique 186 keV gamma ray emitted during natural decay. This is possible because of technological developments which allow the separation of the gamma ray from the general spectrum of radiation. New portable computers which prompt the user with instructions can measure the enrichment of some materials to within one or two percent. It is more difficult to analyse plutonium because of the complex spectrum it produces, but high level neutron coincidence counters can perform this task.

Proposal Abstract D45(G83)

1. **Arms Control Problem:**
   (a) Nuclear weapons - proliferation
   - comprehensive test ban
   (b) Chemical weapons - production

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices - RECOVER

3. **Source:**
   United States. General Accounting Office. Report to the Director, US Arms Control and Disarmament Agency - RECOVER: A Potentially Useful Technology for Nuclear Safeguards, But Greater International Commitment is Needed. Washington, D.C.: January 25, 1983.

4. **Summary:**

This report is an assessment of the potential contribution of the Remote Continual Verification (RECOVER) system designed to assist the International Atomic Energy Agency (IAEA) in administering its system of international safeguards for nuclear facilities. The RECOVER program was initiated in 1976 by the United States Arms Control and Disarmament Agency (ACDA) to help the IAEA improve its use of inspectors. Containment and surveillance equipment (seals and cameras) used by the IAEA is prone to failure; camera failures and film jamming have caused lapses in surveillance which requires inspectors to reinventory a facility's material. RECOVER was designed to monitor the status of containment and surveillance equipment by using on-site multiplexers which transmit status data to IAEA headquarters in Vienna. If a camera monitored by RECOVER were to fail, the monitoring unit would detect the failure and store the data until contacted by the on-site multiplexer. An alert would notify IAEA headquarters which would then decide how to respond.

The objectives of the report were to: (1) identify various assessments of RECOVER's potential benefits to IAEA safeguards, (2) determine the IAEA's position concerning RECOVER, (3) assess the planning, development and programming of the RECOVER project, and (4) ascertain RECOVER's costs to the United States.

A US national laboratory concluded in an initial report that RECOVER would be potentially cost-effective at only a small fraction of the installations under international safeguards in 1981. ACDA officials suggest that RECOVER could provide "valuable but unquantifiable benefits". The IAEA believes that RECOVER might improve the credibility of safeguards, but would not reduce inspection requirements. It is thus unclear what use RECOVER would

have in enhancing safeguards and the project has not been considered urgently needed by US and IAEA officials.

More technical work is needed on some aspects of the RECOVER system. RECOVER cannot monitor the IAEA's existing metal seals, but development of a compatible fiber optic seal has not yet been completed even though it has been worked on for years. IAEA officials believe that remotely monitored fibre optic seals would be "useless" without corresponding remotely monitored intrusion detectors. These detectors (similar to motion- or sound-detecting burglar alarms) should be developed. Changes in the communications function of RECOVER are necessary to overcome low line utilization and successful call rates. The portable verification unit must also be redesigned to make it lighter and less fragile.

Other sensors could possibly be used along with RECOVER in the future. These systems include:

(1) a surveillance television and recording system, unique because of its use of motion detectors and redundant recorders, being developed by Sandia National Laboratories for IAEA (see abstract D51(G84));

(2) nuclear fuel bundle counters and closed-circuit television for CANDU reactors being developed by Canada;

(3) portal monitors under development in Japan for use in fast critical assemblies. However, the IAEA has not yet accepted the portal monitors for routine use in the safeguards system; and

(4) an integrated monitoring system already built by Sandia National Laboratories (see abstract D51(G84)).

The current RECOVER design could not, however, monitor seismic stations used to verify a comprehensive test ban treaty. While RECOVER may have little use in the US domestic safeguards system, Japan is investigating possible applications in its domestic safeguards program.

The IAEA has not yet accepted RECOVER for routine safeguards use, but has cooperated in testing a prototype model since 1979. A decision on acceptance of RECOVER by IAEA was not expected before 1984. The General Accounting Office (GAO) recommends that the Director of ACDA find out from the IAEA what its criteria for acceptance of RECOVER are, assess the RECOVER program and present the results of the assessment to the IAEA, requesting a decision regarding acceptance. The GAO also recommends that ACDA update its cost estimates for developing an operational RECOVER system and determine an appropriate division of responsibilities among US governmental agencies for completing the testing and development of RECOVER.

 D46(I83)

Proposal Abstract D46(I83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   International Atomic Energy Agency. "IAEA safeguards: aims, limitations, achievements". IAEA/SG/INF/4, 1983.
   See also: - "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev. 2, 16 September 1968 (abstract D10(I68)).
   - "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev. 1, June 1972 (abstract D12(I72)).

4. **Summary:**
This document briefly reviews the history and evolution of nuclear safeguards and discusses the role of safeguards in nuclear non-proliferation (sections 1 and 2). Section 3 examines the purposes and objectives of safeguards. A first objective is providing assurance that a state is complying with the NPT (regulated by INFCIRC/153) or other agreements (regulated by INFCIRC/66) it has entered into. Second, if the IAEA is unable to verify that there has been no diversion of the nuclear material required to be safeguarded, then the Director General of the IAEA must inform the Board of Governors which may then decide to invoke sanctions provided for in the IAEA Statutue. Only two cases of inability to provide assurance have occurred so far and both were resolved without sanctions. Third, safeguards serve to deter states from diverting nuclear material for military use. Fourth, in order to make the risk of detection significant, sanctions can be invoked to punish non-compliance. If a state violates a safeguards agreement, the Board of Governors is required to call upon it "to remedy forthwith any non-compliance which it [the Board] finds to have occurred" (IAEA Statute, Article 12(c)). The Board must report the non-compliance to all members of the IAEA, to the Security Council and to the General Assembly of the UN.

Section 4 covers the technical objectives of safeguards. The "detection goals" of safeguards are described by four numerical parameters: (1) significant quantity; (2) detection time; (3) detection probability; and (4) false alarm probability. A significant quantity is defined as "the approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the manufacturing of a nuclear explosive device cannot be excluded" (p. 26). "Timely" detection involves a calculation of the amount of time required to convert nuclear material for use in weapons. This time depends on the type of material used. Frequency of necessary inspections will therefore vary. Containment and surveillance measures can aid timely detection. Sealing material not in active use means that repeated measurements and verification of that material is unnecessary. Estimates of detection probability can currently be quantified only for materials accounting. Sampling techniques are used to provide maximum detection capability with minimum effort. The IAEA tries to achieve a 90-95% detection probability level and less than 5% probability of false alarms.

The conclusion drawn for the past five years in the annual Safeguards Implementation Report prepared by the Secretariat of the IAEA has been that "all safeguarded material remained in peaceful nuclear activities or was otherwise adequately accounted for" (p. 32). The credibility of this conclusion is attested to by the fact that no one has challenged the conclusion and no overt signs of diversion of safeguarded material have been detected.

The document also points out the limitations and practical problems faced by the IAEA: (1) States accept safeguards voluntarily and the IAEA has no power to compel any country to sign a treaty or agreement. (2) Safeguards agreements concluded in the late 1960s have had to be modified to bring them up to today's standards, but this has taken lengthy negotiations. (3) The IAEA has no enforcement powers. It may invoke sanctions in response to a violation of obligations, but it cannot prevent violations nor can it force any state to comply with directives issued by the Board of Governors. (4) The powers of inspection of the IAEA are limited by the willingness of states to report all nuclear material involved in civilian nuclear activities and to allow the free movement of inspectors. (5) The IAEA has some problems in designating inspectors because some states have refused entire categories of inspectors on the grounds of nationality. (6) Despite increases in budgetary allocations for safeguards, the funds available for the safeguards operation are inadequate. (7) There are a number of restrictions placed on the IAEA and its inspectors which require caution to avoid interfering with economic development or the construction or operation of facilities. (8) The IAEA is required to take precautions to protect commercial and industrial secrets which may be revealed during the application of safeguards. The publication of such information is strictly controlled. (9) The IAEA must not

discriminate between member states in applying safeguards. In practice, this means the use of the same number of inspection man-days per year regardless of the type of fuel cycle used by a country. It might be more efficient to vary the inspection effort, but this would require a complex, time consuming revision. (10) The State's System of Accounting for and Control (SSAC) of nuclear materials can be improved in many countries. Operators of facilities should be required by governments to keep accurate records and send them promptly to the IAEA. IAEA training courses may help to improve the implementation of the system.

Despite these obstacles, the IAEA has established a functional safeguards system which contributed to success in negotiating and verifying the NPT. The system also facilitates safe and efficient international trade in nuclear facilities and materials.

Proposal Abstract D47(A84)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Gruemm, H. "Safeguarding the Fuel Cycle: Methodologies". IAEA Bulletin 26, no. 3 (September 1984): 20-24.
   See also: - International Atomic Energy Agency. "The Agency's safeguards system (1965, as provisionally extended in 1966 and 1968)". INFCIRC/66/Rev. 2, 16 September 1968 (abstract D10(I68)).
   - International Atomic Energy Agency. "The structure and content of agreements between the Agency and states required in connection with the Treaty on the Non-Proliferation of Nuclear Weapons". INFCIRC/153/Rev. 1, June 1972 (abstract D12(I72)).

4. **Summary:**

Gruemm considers possibilities for improving safeguards methodology to reduce manpower requirements without causing a loss of effectiveness. In this regard, some studies have suggested that the IAEA adopt a "fuel cycle-oriented approach" rather than its current individual "facility oriented approach". Gruemm points out, however, that current methods do account for the characteristics of the national fuel cycle. For example, safeguards must be designed differently for application under the INFCIRC/66 agreement since not all nuclear facilities need be covered and the possibility of nuclear material flows from unsafeguarded facilities to safeguarded facilities must be anticipated. Furthermore, differentiation among types of facilities is required by paragraph 6(c) of INFCIRC/153 which provides for concentration of verification effort at stages of the nuclear fuel cycle at which weapons-usable nuclear material could be produced.

One possible modified approach is to group nuclear facilities into four categories according to their individual "diversion risk", i.e. according to the type and quantity of nuclear material present. Verification in countries with facilities incapable of producing weapons-usable material could be halted. This could be compatible with the situation in which, in 1983, almost 70% of the inspection effort was spent in 5 of the 50 states visited by IAEA inspectors. This proposal would affect about 26% of the total inspection effort.

However, this proposal would likely be unacceptable because: (a) the IAEA is legally bound by its Statute to perform verification at all facilities covered by the agreements; (b) the cessation of verification activities in certain states could be considered discriminatory or unacceptable by other states; and (c) IAEA safeguards would lose some credibility because some plausible diversion hypotheses would be ignored. Nonetheless, it might still be possible to make verification activities less stringent for particular fuel cycle types and thereby cause only a slight reduction in detection probability.

Another possible approach is to make random inspections at a few selected facilities in cases where the national fuel cycle uses power reactors of the same type. This might have a deterrent effect, but it suffers from a number of drawbacks. Procedures necessary for inspections such as visa applications and availability of accompanying staff would give an early warning to a prospective diverter. More important, however, is the necessity of careful advance preparation by the operator (updating files, etc.) and proper selection of the appropriate operating phase of the facility. Gruemm estimates that only a 5% reduction in required inspection effort would result from this approach.

The first approach seems to hold out better prospects for savings in inspector manpower, if certain diversion assumptions are dropped and the desired detection probability is reduced, but the effects of such modifications should be studied very carefully.

Proposal Abstract D48(A84)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
(a) On-site inspection - IAEA safeguards
(b) Short-range sensors - monitoring devices
- seals

3. **Source:**
Rundquist, David and Leonard Watkins. "Improving Safeguards Techniques: Instrumentation". IAEA Bulletin 26, no. 3 (September 1984): 13-19.

4. **Summary:**
This article briefly reviews representative examples of research and development projects which aim to increase the efficiency of the International Atomic Energy Agency by improving safeguards techniques. The particular characteristics which distinguish safeguards equipment from typical industry equipment are a product of special requirements for safeguards. For example, since containment and surveillance equipment must function reliably when unattended for the two or three month period between inspections, the Agency must develop durable, reliable equipment and must carry out a comprehensive preventive maintenance programme. Time pressure on inspectors to perform non-intrusive, rapid inspections necessitates that instruments be easy to use, that they "prompt" the inspector during the measurement process and that they be self-calibrating. The operation of monitoring instruments must be independent of nuclear station operations because facility operators will give low priority to safeguards equipment failures since safeguards are a non-commercial requirement.

Safeguards equipment is designed with the above requirements in mind. Portable mini-multichannel analysers display and record gamma-ray spectra obtained from radioactive samples. "User-friendly" software used in the instrument prompts the inspector during the procedure to set up the instrument. Bundle counters for Candu on-line fuelled reactors use Geiger-tube sensors connected to a microprocessor-based electronics package. The instrument is highly reliable, easily maintained and tamper-resistant. A performance monitoring programme to test the field performance of all routinely employed safeguards equipment has been in operation since May 1983 on

safeguards equipment in four Candu 600-megawatt reactors under the Canadian Support Programme. Another programme has analysed various approaches to applying safeguards (both material balance accounting and containment and surveillance techniques) to large heavy-water production plants.

The article contains pictures of monitoring devices with explanations.

Proposal Abstract D49(A84)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Schiff, Benjamin. International Nuclear Technology Transfer: Dilemmas of Dissemination and Control. Totowa, New Jersey: Rowman and Allanheld, 1984.

4. **Summary:**

   This book covers the history of international efforts to control the spread of nuclear weapons technology. Chapter three (pp. 93-159) discusses nuclear safeguards and security. Schiff maintains that "safeguards implementation has undoubtedly improved" (p. 153). The greater use of quantification, increasingly technical, rather than political, administration of the safeguards division of the IAEA, expanded research and development in safeguards equipment and methods, and improved coordination of safeguards at the IAEA level and within the state systems of accounting for and control of nuclear materials have all contributed to improvements in safeguards performance. However, these technical considerations are often overshadowed by political disagreements over the merits of the non-proliferation regime. In particular, developing countries have resisted safeguards because they undermine sovereignty and are not accompanied by the technology transfers which were promised in the Non-Proliferation Treaty.

   The chapter covers the negotiations over safeguards agreements, the implementation of safeguards rules and efforts to improve safeguards. Because of political resistance, "the Agency has continually found its material capabilities and political mandate to lag behind the potential scope of safeguards" (p. 95). Furthermore, there are technical obstacles to safeguards implementation. Large material flows must be accounted for and the IAEA has only limited access to some nuclear fuel stocks, spent fuel ponds, reprocessing, enrichment and fabrication facilities and to some kinds of reactors. Only recently have nuclear facilities been designed with safeguards in mind.

Safeguards for the following facilities and equipment are discussed: light water reactors, on-load fueled power reactors, conversion and fabrication plants reprocessing plants, uranium enrichment plants and fast breeder fuel cycle facilities. Table 3.2 (pp. 108-111) lists the facilities under IAEA safeguards between 1977 and 1981. Table 3.3 (p. 112) shows the amounts of nuclear materials under safeguards (1968-1981). Tables 3.9 (p. 121), 3.10 (p. 123), 3.11 (p.126) and 3.12 (pp. 128-131) list the diversion possibilities, concealment methods and safeguards measures used with the equipment and facilities listed above.

Proposal Abstract D50(A84)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Tempus, Peter. "Progress in Safeguards: 1983 Implementation". Bulletin 26, no.3 (September 1984): 7-12.

4. **Summary:**

This article reports on progress and development in IAEA safeguards implementation. Table 1 (p.8) shows that the inspection effort (measured in man days of inspection) increased by about a third from 1981 to 1983. Attainment of inspection goals has also risen from 17% in 1978 to 46% in 1983 for the facilities inspected, and from 48% to 64% in the case of highly enriched uranium and plutonium in these facilities. The sensitivity of inspection and evaluation activities is quite high; in 1983 more than 420 minor anomalies were discovered, but all, except one which was still under investigation, were satisfactorily explained.

The IAEA faces some problems in implementing safeguards. Some states submit their reports after the agreed deadlines and there is often insufficient data on uncertainties in the operators' measurements so that the Agency has to make its own estimates. Technical procedures for standardized reporting of international transfers of nuclear material proposed by the IAEA have been followed erratically so that reconciling data from shipping and receiving states has been difficult. The use of a Cerenkov glow measuring device for verifying spent fuel has been hampered by national regulations on facility lighting, but devices which can operate under ambient lighting conditions were tested in 1983 with good results. The routine use of these devices in inspections has not yet been approved.

Equipment failures were down from 9% in 1981 to 3.6% in 1983 and further improvements may result from technological developments. New equipment was field tested and evaluated. These items included: a portable analysis unit for plutonium isotopic measurements; equipment for the simultaneous measurement of gamma radiation and neutrons from irradiated fuel assemblies; and special detector heads for high-level neutron coincidence counters for carrying out measurements of plutonium in chemical and physical forms. Increased efficiency in manpower utilization may help the Agency meet inspection goals with minimum intrusiveness. New recruitment procedures are eliminating excessive replacement delays and inspection assistants have freed experienced inspectors for more complicated work. Improvements in the electronic processing of safeguards data have also increased the efficiency of the safeguards system.

Proposal Abstract D51(G84)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
(a) On-site inspection - IAEA safeguards
(b) Short-range sensors - monitoring devices
- seals

3. **Source:**
United States. Department of Energy. Sandia National Laboratories. "Instruments for Verifying International Safeguards Agreements". Sandia Technology 8, no. 2 (November 1984): 16-19.

4. **Summary:**
This article discusses Sandia Laboratories' work on instruments intended to assist the International Atomic Agency (IAEA) in monitoring compliance with the Non-Proliferation Treaty (NPT, 1968). Sandia has developed two television systems to continuously monitor areas for possible material movement. The larger system STAR (Surveillance Television and Recording System), is designed for permanent installation at sites such as spent fuel storage areas at reactors. Pictures are recorded at intervals of a length such that no activity is possible between pictures, but not so frequently that an inordinate number of images must be inspected. Motion detectors cause the two STAR cameras to operate automatically, if there is activity in their field of view. An IAEA inspector visits the site approximately every three months and reviews the images recorded by STAR. The system includes sensors to detect several kinds of tampering. In general, Sandia has been more concerned with tamper detection than tamper resistance. An attempt has been made to identify and deal with every credible means by which someone could frustrate these monitoring systems and mislead an inspector without leaving evidence of his actions.

MINISTAR, the second Sandia system, is a portable, compact television system which can be used for both short- and long-term surveillance. It has one video camera, recording equipment and tamper protection.

Sandia's Integrated Monitoring System (IMS) can be used in facilities in which television is not possible or unnecessary. It is a distributed system that can collect, analyse and record data from a variety of sensors which may detect, among other things, radiation levels, temperature and motion. The IAEA inspector has access to the data through a portable keyboard and printer. It too is designed to detect tampering.

Among the tamper detection devices developed by Sandia are anodized aluminum casings which change colour if the housing is penetrated and camera cable shielding. Another device is multifiber optical cable which must be cut in order to get access to a sealed unit. When the seal is made, the fibers are randomly cut and the light signature is photographed for comparison with later inspections. This allows detection of unauthorized entry.

The article contains useful pictures and graphs.

 D52(I84)

Proposal Abstract D52(I84)

1. **Arms Control Problem:**

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   (a) On-site inspection - IAEA safeguards
   (b) Short-range sensors - monitoring devices
   - seals

3. **Source:**
   International Atomic Energy Agency. "IAEA safeguards: safeguards techniques and equipment". IAEA/SG/INF/5,1984.

4. **Summary:**

Nuclear material accountancy is the basic verification measure used by the IAEA. Containment and surveillance equipment is used to complement this method and reduce the frequency of verification. Independent verification methods are required to confirm the accuracy of material accountancy reports. This document surveys the equipment used for this task and describes containment/surveillance (C/S) equipment.

Non-destructive analysis measures the gamma rays and neutrons emitted by various nuclear materials. The techniques for this analysis covered in the booklet include: (a) gamma spectometry; (b) neutron counting methods; (c) Cerenkov glow observation to verify the quality of irradiated fuel in storage pools; (d) measurement of radiation from spent fuel; (e) calorimetry; and (f) weighing items containing nuclear materials.

Containment/surveillance equipment described includes: (a) photographic surveillance equipment; (b) television surveillance; (c) sealing equipment (fibre optic seals or ultrasonic seals); (d) reactor power monitors; (e) underwater surveillance instruments; (f) radiation dosimeters; (g) bundle counters and (h) the Remote Continual Verification (RECOVER) system (see abstract D45(G83)). Pictures of the devices are included.

Proposal Abstract D53(A85)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Blix, Hans. "Nuclear Power Without Nuclear Weapons." New Scientist no. 1470 (22 August 1985): 36-39.

4. **Summary:**
   The IAEA safeguards system is designed to detect and identify anomalies in nuclear materials accountancy reports submitted by states to the IAEA which would indicate the diversion of nuclear materials to non-peaceful purposes. Safeguards are designed according to the characteristics of each plant and inspectors verify by counting, measurement and other means that the amounts of nuclear material actually present in a facility correspond to the operating records and reports made by facility operators. Non-destructive assay techniques which analyze materials without physically affecting them and destructive techniques such as chemical analysis are an important part of the verification process. Containment and surveillance measures which use sealed storage containers and automatic cameras and electronic aids complement nuclear material accountancy.

   A test of the safeguards system occurred in 1984 when a shipment of depleted uranium was exported from Luxembourg to Israel without due notification of the IAEA. Blix reports that the safeguards system detected the anomaly within the timeliness goals that had been established. Israel later reported that the material had been imported for non-nuclear non-explosive purposes and IAEA inspectors were permitted to examine a large part of the material.

 D54(A85)

Proposal Abstract D54(A85)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
On-site inspection - IAEA safeguards

3. **Source:**
Patrick, B.H. "Safeguards Practices Benefit From Advances in Data Processing." Atom No. 346 (August 1985): 17-20.

4. **Summary:**
This article reports on a symposium held by the European Safeguards Research and Development Association (ESARDA) in Liège, Belgium from 21 to 23 May 1985. The theme of the symposium was 'the impact of advances in data processing on safeguards practices' and topics discussed mainly focussed on the development of existing safeguards techniques rather than on new methods.

A paper by Von Baeckmann reported that sophisticated data processing hardware and software are helping to maintain the high standard of IAEA safeguards effectiveness. A centralized computer system collects, stores and evaluates safeguards data and information. Ispra's paper described a different computer-based materials accounting system which uses ten personal computers instead of a centralized system. This system reportedly costs less, is more available and can be adapted to changing requirements more easily than the centralized system. Microprocessors and personal computers have been used in on-site inspections in recent years to provide user-friendliness in prompting responses, data quality checks, in-field analysis and instrument performance monitoring. Future developments will likely produce equipment capable of testing and calibrating itself automatically.

In the past, Euratom (the European Atomic Energy Agency) safeguards have not been based on either a minimum quantity of material or maximum time with regard to the detection of diversion. These parameters have now been quantified and the paper by Gemelin *et al*. explains how the inspection goals were implemented at two typical types of plants.

New developments in non-destructive assay equipment can help safeguard against the possible clandestine use of centrifuge enrichment plants to produce highly enriched uranium. High performance neutron coincidence counters for this purpose have been tested at Euratom facilities in Luxembourg.

A paper by Zucker described a non-intrusive method for the assay of heavy water. This would facilitate monitoring of heavy water plants which fall within the scope of the NPT.

A new laser surveillance system described by Fiarman et al. may remedy some of the problems associated with the conventional camera surveillance system. The conventional system, which takes pictures spaced five to twenty minutes apart, cannot determine the number of assemblies loaded into casks for shipment away from the storage pool. It also requires adequate facility lighting and the time-consuming review and analysis of pictures. The laser surveillance system does not face these problems. It uses two beams of blue light to scan an underwater plane just above the fuel assemblies in their storage racks in a spent fuel storage pond. When an assembly is raised from or lowered into a rack, it breaks the plane of light and a computer records the change and the position of the disturbance in the pool. A paper by Collier and Luchtmans, however, contended that the conventional cameras were of greater utility to inspectors than a computerized monitoring system.

A number of papers presented models for estimating measurement errors in materials accountancy. A paper by Rogers and Hooton suggested that, using neutron coincidence counters, measurements would be accurate to within 5% for small and medium sized samples and to within 10% for large samples. Jones' paper described developments in the application of Page's test to search for anomalies in accountancy data that could represent abrupt diversions. This method should allow near real time materials accountancy to be incorporated at the plant design stage.

Proposal Abstract D55(A85)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   On-site inspection - IAEA safeguards

3. **Source:**
   Posey, C. "The Inspectors". Science 85 (December 1985): 44-51.

4. **Summary:**

The author takes the reader through a hypothetical IAEA inspection of a safeguarded nuclear reactor. He provides considerable detail about the inspection methods and sensors used as well as the rationale behind them. Problems which might be encountered both at a technical and a human level are discussed. Some of the human tensions faced by inspectors are suggested. As the author points out, "it is not all measurements, or all cut and dried. The inspector must be sensitive to every nuance of his host's behaviour and to the physcial facility as well" (p. 50).

Posey next briefly reviews some of the difficulties diverters would face in trying to beat the safeguards system. Special attention should be given to uranium enrichment plants and uranium reprocessing plants because they can produce significant amounts of weapon-grade material. "Ominously, the two percent of nuclear facilities not under international safeguards are not power reactors" but are fuel enrichment and reprocessing plants in countries which have failed to ratify the NPT (p 51).

Safeguards officials claim a 90% chance of detecting nuclear diversions and most nations seem to believe this. Inspectors can also take anomalies they discover to the 35 nation Board of Governors of the IAEA to get them sorted out.

Proposal Abstract D56(I85)

1. **Arms Control Problem:**
Nuclear weapons - proliferation

2. **Verification Type:**
On-site inspection - IAEA safeguards

3. **Source:**
International Atomic Energy Agency. "IAEA Safeguards: Implementation at Nuclear Fuel Cycle Facilities". IAEA/SG/INF/6, 1985.
See also: - "IAEA safeguards: Aims, limitations, achievements". IAEA/SG/INF/4, 1983 (abstract D46(I83)).

4. **Summary:**
This document provides a detailed description of the application of IAEA safeguards to various types of nuclear facilities. It reviews the purposes and technical objectives of safeguards (see Abstract D46(I83)) and elaborates upon the inspection goals of safeguards. Detection goals are one of several factors which determine the inspection goals. The accountancy verification goal is "the minimum quantity of nuclear material which, if diverted at a facility, should (to the required degree of probability) be detected by the application of nuclear material accountancy measures alone with a low risk of false alarm" (p.6). For most facilities, this amount is equal to one significant quantity (SQ), i.e. the amount of nuclear material which would be necessary to construct a nuclear device. The timeliness goal is determined by adapting the detection time guidelines to the specific characteristics of a facility. The frequency of inventory verification and containment/surveillance activities will also depend on the safeguards resources available. The timeliness goals currently range from four weeks for facilities handling one SQ or more of high enriched uranium or plutonium in non-irradiated form to twelve months for those handling low enriched uranium or natural uranium.

Chapter 2 of the booklet covers the methodology of safeguards in greater detail than many other IAEA publications. It explains: (1) safeguards measures (section 2.1); (2) diversion analysis, i.e. analysing potential diversion strategies, potential routes and concealment methods and identifying related anomalies (section 2.2); and (3) inspections (section 2.4.1 specifies whether thirteen specific inspection activities are related to nuclear material accountancy or to containment/surveillance). The effectiveness of safeguards is difficult to quantify in the absence of detected diversion acts, but in order to improve effectiveness, the IAEA hopes to increase the number of facilities in which the inspection goals are fully attained and to improve the overall detection probability.

Chapter 3 describes the specific safeguards approach for various nuclear facility types. The main components of the approach consist of: (1) design and operations characteristics of the facility; (2) a designated material balance area with identified strategic points and key measuring points; (3) possible diversion and concealment assumptions and related anomalies; (4) inspection goals determined by facility characteristics and legal and technical constraints; (5) recording and reporting requirements; (6) special nuclear material accountancy features; (6) appropriate combinations of containment/ surveillance measures and their installation at strategic points; (7) the frequency, duration, timing and mode of routine inspections; and (8) the particular inspection activities to be carried out during routine inspections in a typical nuclear material accountancy cycle. The approaches for the following types of facilities are explained: light water power reactors; research reactors; critical assemblies; on-load fuelled power reactors; fast breeder reactors; storage facilities; conversion and fuel fabrication plants (low enriched uranium, high enriched uranium and mixed oxide, i.e. uranium and plutonium); reprocessing plants; and enrichment plants.

Proposal Abstract E1(A62)

1. **Arms Control Problem:**
General and complete disarmament

2. **Verification Type:**
(a) On-site inspection - progressive/zonal
(b) Remote sensors - aerial
(c) International exchange of information - declaration
(d) Non-physical/psychological inspection

3. **Source:**
Sohn, Louis B. "Progressive Zonal Inspection: Basic Issues". In Disarmament: Its Politics and Economics, pp. 121-133. Edited by Seymour Melman. Boston: The American Academy of Arts and Sciences, 1962.

4. **Summary:**
The American "Outline of basic provisions of a treaty on general and complete disarmament in a peaceful world" submitted to the Eighteen Nation Disarmament Conference in April 1962 (see abstract P15(G62)) contains provisions for progressive/zonal inspection to verify declarations of armament levels. This article considers various approaches to selection of zones and focusses on the problem of size and number of zones. The implications of this type of inspection for military security are considered throughout the discussion.

The American proposal calls on parties to divide their territory into an agreed number of zones and to provide an inventory of armaments, forces and specified types of activities subject to verification within each zone. Only numbers, not specific locations, would be declared, but, depending on the number of zones agreed upon, it would be possible to locate military resources with varying degrees of accuracy. For example, if there were a small number of zones (ten or twenty) then the information that there are twenty missile launching pads in one zone would not be militarily useful, but if there were fifty zones then the location of the pads within a zone could be estimated with greater precision. Two approaches to zonal inspection are thus possible: the small zone method and the large zone method.

A large number of small zones (say fifty) would enable a verifying party to locate forces within a zone with greater accuracy than in the large zone method, but this would probably still not allow the pinpoint precision necessary for targeting forces. This method of verification would therefore not pose a military threat. If a group of states were allowed to select ten or twenty small zones in each of the territories of another group of states, they might gain a large amount of military information by selecting the most significant areas in the first stage of the process. If, however,

only one zone were to be inspected during each step, the parties would have to develop procedures for sealing the borders of the zone to prevent clandestine movements of armaments. Rapid sealing is more feasible in the small zone method. Sealing the borders would also be necessary in the large zone method, but this might be more acceptable since intrusiveness would be less than in a small zone method involving inspection of several zones during each stage of disarmament.

Some proposals suggest stationing inspection teams on the boundaries of all the zones and at major rail and road centers and airfields at the time of the selection of the zone. Sohn proposes another method which might perform the same function, but at the same time reduce the risk of acquiring military information outside of the selected zone. Inspection teams could be transported by the inspected country to major airports, railway stations and highway centers within each zone prior to the selection of the zone which will be inspected. Their movement might be restricted while waiting for a zone to be selected. After notification of the selection of a zone, the inspectors stationed in that zone would be given complete freedom of movement in it. Inspectors in neighboring zones would then be authorized to proceed to the boundaries of the selected zone and to check all the vehicles and railway cars which might have left the zone after its selection but before the establishment of inspection posts on the boundaries. If states were required to submit a detailed list of armaments and facilities subject to control after the selection of the zone, the inspectors could check the accuracy of the list and the presence of armaments and facilities not accounted for. Some of these procedures might also be useful in the small zone method.

States may draw the boundaries in the large zone method in such a way as to minimize the disclosure of military secrets, thereby balancing the military risks involved in selecting one zone rather than another.

Instead of using a division of countries, zonal inspection could utilize a division by military blocs. For example, the territories of the European members of NATO could be divided into ten zones which cut across national boundaries. Similarly, the Asian part of the Soviet Union and the United States and Canada could each be divided into ten zones.

All of the zonal approaches should permit aerial and mobile ground inspection, access to public and private buildings (as provided for in the disarmament agreement) and the interrogation of public and private persons (as provided for).

Proposal Abstract E2(A62)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   - control posts
   (b) International control organization
   (c) International exchange of information

3. **Source:**
   Sohn, L.B. "Territorial Arms Control: A Proposal". In Arms and Arms Control, pp. 209-218. Edited by E.W. Lefever. New York: Praeger, 1962.

4. **Summary:**

This proposal presupposes the establishment of continuous on-the-spot controls over certain activities or establishments, and unrestricted mobile inspection teams looking for clandestine activities in violation of the disarmament agreement. Assuming that fixed control posts are generally acceptable, this proposal attempts to meet objections to mobile inspection by suggesting that each cut in armaments could be accompanied by the extension of mobile inspection only to a specified part of a nation's territory, proportional to the total arms reduction at each step.

At the beginning of the disarmament process, each country would submit to an International Disarmament Organization (IDO) two lists, one enumerating all facilities to be subject to constant surveillance by fixed teams, the other listing the national totals of various armaments, installations and production facilities subject to control, as well as regional totals of these. A thorough inspection of one randomly-chosen region would verify the accuracy of the lists. This initial choice of the region would be made by the IDO or by the other parties to the agreement and no prior notice would be given to the inspected country. In order to prevent late minute shifts between regions, inspection teams would be stationed on the borders between regions and at principal rail, road, and airfield centres. Once the region to be inspected has been chosen, the teams on the boundaries of the selected region would remain in place while other teams would be withdrawn from the boundaries of the unselected regions and would assist in the inspection of the selected region. Immediately after the selection, the nations concerned would submit a detailed list of armaments and other objects of control located in the selected region, the totals of which should not differ significantly from the general list submitted in advance. The inspection teams would verify the accuracy of the list and would supervise the actual process of disarmament within the region.

This process would be repeated with each new stage of the disarmament process.

Proposal Abstract E3(A62)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   On-site inspection - progressive/zonal

3. **Source:**
   Sohn, L.B. "Zonal Arms Reduction to a Minimum Deterrent". Verification and Response in Disarmament Agreements, Annex V-1. I, Appendix A, Woods Hole Summer Study, Institute for Defense Analysis, Washington, D.C., November 1962, pp. 47-50.

4. **Summary:**

Proposals for a zonal approach to disarmament are usually based on either "zonal disarmament" (i.e. the total disarmament of one zone after another) or on "zonal inspection" (i.e. the progressive inspection of one zone after another, without any obligation to disarm a particular zone):

> A third approach might be possible, under which each nation would be permitted to retain a specified number of strategic weapons in each inspected zone, would destroy a specified number under international supervision, and would destroy the undeclared excess prior to the beginning of the inspection. Under this system there would be no need for an initial declaration of the total number of weapons or of the number of weapons in each zone. Nations would be safeguarded by keeping their own minimum deterrent forces (a specified number of weapons per zone) until the very end of the disarmament process.
>
> In practice, this method might work as follows: each state would divide itself into a specified number of zones, for example, ten. As a matter of self-interest all states would probably distribute their military strength as evenly as possible among their zones in order not to lose too much if one zone rather than another were chosen for inspection and the destruction of weapons above the permitted minimum.
>
> During the initial period of each disarmament step, the inspectors in the selected zone would have only one function: to check on the inter-zonal traffic to the extent necessary to insure that no weapons subject to destruction are being moved out of the zone. The inspected nation would be given a specified period, let us say one month, to destroy all surplus weapons in the zone; after the end of that period the inspectors would be permitted to move throughout the zone to verify the fact that only the agreed quantity of weapons needed for a minimum deterrent remained in the zone and that the remainder

had been properly destroyed. All the permissible weapons would be permanently numbered by the inspectors, possibly with a special radioactive paint which cannot be duplicated, and their inspection thereafter would be limited to the checking of the number.

After the verification process if completed, another zone would be chosen and the process would be repeated. Each of the inspected zones would remain permanently subject to further inspection on a random basis in order to insure that new weapons had not been produced clandestinely. These later inspections might be limited to a certain number of inspections per year and to a specified percentage of weapons in order to avoid releasing too much information about deployment.

Upon the completion of the first phase of the disarmament process, the weapons of the two main power blocs would have been reduced to the agreed minimum deterrent, and there would have been a sufficient amount of inspection to insure that a significant number of strategic weapons had not been hidden. At the same time, this approach would avoid disclosure of any current inferiority in numbers of strategic delivery vehicles, since inspection of each zone would take place only after an unknown number of delivery vehicles in each zone had been destroyed.

 E4(A62)

Proposal Abstract E4(A62)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   (b) Remote sensors - aerial

3. **Source:**
   Sohn, L.B. "Zonal Disarmament and Inspection: Variations on a Theme", Bulletin of the Atomic Scientists 18, no. 7 (September 1962): 4-7.

4. **Summary:**
   Two variations on the theme of progressive/zonal on-site inspection are offered.
   (1) The country to be inspected divides its territory into an agreed number of zones, ten for instance, and the inspectorate choses one of the zones for disarmament. There would be no need for inventories. This follows from the idea that no nation would know in advance which zone would be chosen and would therefore be likely to create its zone with an eye to distributing its military strength evenly so as not to lose too much if one zone is selected rather than another. Once a zone is chosen, the inspectors would seal its borders in order to make sure no weapons were removed from it. The inspected country would then proceed to demilitarize the zone, and only after this was done would the inspectors enter. The inspectors would check that all weapons had been destroyed and that there were no factories still producing weapons in the zone. Upon completion of these tasks, the inspectors would proceed to another zone.
   (2) To verify an agreement that includes, say, a 10% reduction in all major armaments and a strict limitation on the production of new weapons, a somewhat different verification technique is proposed. Each country would divide its territory into 10 zones for example. It would then submit to an International Disarmament Organization (IDO) a declaration stating the total level of all armaments in each zone and giving the location of facilities for production of armaments. The IDO would then verify that production of armaments had ceased, by on-site inspection where necessary. Thus only locations of production facilities, not of armed forces or armaments, would be provided to the IDO. Next the IDO would select a zone for disarmament, and would be provided with a more detailed inventory of forces and arms in the zone, locations included. Arrangements would be made to ensure that movement of arms and forces did not occur between zones. Various methods of verifying this are mentioned. Inspection by both ground and aerial inspectors of all relevant objects would then proceed within the zone.

Proposal Abstract E5(A63)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   (b) Remote sensors - aerial
   (c) Records monitoring - economic
   \- personnel

3. **Source:**
   Rodberg, L.S. "Graduated Access Inspection". In Weapons Management in World Politics: Proceedings of the International Arms Control Symposium, December 17-20, 1962, pp. 39-144. Edited by J.D. Singer. Ann Arbor, Michigan: 1963.

4. **Summary:**
   "Graduated access inspection seeks inspection procedures for detecting clandestine production and verifying levels of retained armaments which will be appropriate and acceptable at each stage of disarmament." Under this system, the access of the inspectors to the economic, political, social and military activities of the inspected nation increases with the progress of disarmament. The way in which access can be best graduated is by progressively increasing the number of inspectors, thereby increasing the intensity of the inspection. While all sizeable areas of the country would be subject to inspection from the outset of the disarmament process, the frequency and intensity with which the inspectors' rights of entry into these areas can be exercised are limited at the beginning and increase as disarmament proceeds.

   The progression in which the increase in inspection would develop might be based on the sensitivity of the objects of inspection. For instance, areas presently open to foreigners might be dealt with early in the process while production facilities, military bases, etc. might come later.

   Mobile ground inspection teams, aerial inspection, economic and personnel records monitoring are all suggested as integral parts of the system.

Proposal Abstract E6(A64)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   - selective
   - general

   (b) Remote sensors - aerial
   (c) International exchange of information
   (d) International control organization

3. **Source:**
   Clark, Grenville and Louis B. Sohn. "Draft of a Treaty Establishing a World Disarmament and World Development Organization Within the Framework of the United Nations". In Current Disarmament Proposals as of March 1, 1964, pp. 61-182. New York: World Law Fund, 1964.

4. **Summary:**

This proposal envisages the creation of a complex scheme to implement disarmament and to maintain peace in a disarmed world. One of the elements of the proposed World Disarmament and World Development Organization would be a United Nations Disarmament Authority which in turn would contain a United Nations Inspection Service (UNIS) under a five member UN Inspection Commission. UNIS would be headed by an Inspector-General who would be responsible for the administration of the Service and recruitment of its staff.

One of the tasks of UNIS would be to verify the taking of an arms census of every nation of the world (Article 35). To do this each country will delineate ten zones of its territory as inspection areas, each containing about one tenth of all its military resources. In each six-month period of the actual disarmament process, one of these areas, chosen by the Inspection Commission, will be completely inspected by UNIS. The inspectors will verify force level information provided earlier by the countries. Each six months of the disarmament process (which lasts 5 years) nations will reduce their total forces by 10% (Article 40). At the same time that it is verifying the accuracy of the arms census information, UNIS will verify the reduction in force levels (Article 43). Once one of the zones has been inspected it will remain open to inspection at any time.

When the disarmament process has been completed, UNIS will still be used to monitor compliance with restrictions on numbers and types of permitted forces and with arms production licensing requirements (Article 48). The inspection duties of UNIS will also include monitoring nuclear facilities.

UNIS inspectors will be given such freedom of access to the territory of every nation as is necessary for them to do their duties. They will be obligated not to disclose confidential information not related to disarmament (Article 50).

UNIS will verify reductions in forces by observing the disbanding of troops and the destruction of arms and facilities. It will verify the observance of the arms truce by stationing permanent inspection teams at key production facilities and by periodic inspections of other facilities. The progressive verification of the accuracy of the arms census and levels of forces will be done by sealing off each zone using control posts and then thoroughly inspecting the selected zone (Article 51).

Aerial inspection will be restricted during the disarmament process to those zones being or having been inspected. After disarmament is completed UNIS will be entitled to conduct aerial surveys giving notice (Article 54).

 E7(A65)

Proposal Abstract E7(A65)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   On-site inspection - progressive/zonal
   - sampling

3. **Source:**
   Bloomfield, L.P. and L. Henkin. "Inspection and the Problem of Access". In <u>Security in Disarmament</u>, pp. 107-122. Edited by R.J. Barnet and R.A. Falk. Princeton, New Jersey: Princeton University Press, 1965.

4. **Summary:**

This proposal suggests measures that would permit sensitive areas to remain uninspected during the early stages of disarmament. Each party to a disarmament agreement might designate restricted areas containing facilities that would be opened progressively to inspection. Access to the remainder of the country and perimeter inspection of restricted areas could be maintained in order to provide a reasonable degree of confidence that significant violations were not taking place during the early stages.

As the disarmament process proceeds, perimeter observation of the restricted areas and facilities could give way to arranged tours of these areas, then to unannounced tours and inspections of communications centres and contents of transportation carriers. Finally, detailed searches of facilities would be undertaken.

This proposal seeks to meet another problem as well, namely the verification of agreed levels of armaments. It is suggested that identification indices would be assigned to each declared armament and military unit. These might be ordinary serial numbers attached to all items. Each inspection team would have a master list of all armament numbers. The possession either of an item that did not bear a number on the master list or of two armaments bearing the same number would constitute a violation. As such, the object of inspection would be to discover undeclared armaments rather than to count declared ones. This would permit the use of sampling techniques, thereby reducing both the required number of inspections and the amount of sensitive military information disclosed.

Proposal Abstract E8(G63)

1. **Arms Control Problem:**
   Regional arms control

2. **Verification Type:**
   (a) On-site inspection - progressive zonal
   (b) Remote sensors - aerial

3. **Source:**
   United States. Arms Control and Disarmament Agency. Progressive Inspection for Disarmament: The Concept of Progressive Zonal Inspection. Publication 13, January 1963. US 1 AC1 PO 13.

4. **Summary:**

This pamphlet outlines the verification method known as progressive/zonal inspection. It provides highly detailed instructions on the procedure for implementing this verification scheme, and includes a number of charts for the selection and inspection of zones. Progressive/zonal inspection is premised on the need for verification both during and after reductions have taken place. The adequacy of verification will depend on the extent of disarmament being contemplated and the attendant degree of risk involved. Verification must monitor both the reduction of arms and arms levels before and after reductions have taken place.

There are six basic activities which are to be observed by progressive/zonal inspection. These are the destruction of armaments, the conversion of armaments, reductions in force levels, halts in production, testing and other activities, and the detection of undeclared production or testing. The agreed upon arms levels will also be verified through progressive/zonal inspection. This verification scheme should ensure that no side gains an advantage and should also provide a 'realistic degree of assurance' of compliance. Progressive/zonal inspection is advantageous in that it only requires a small disarmament organization for its implementation and is thus easier and cheaper to administer.

Basically, progressive/zonal inspection requires the timed inspection of an agreed number of designated zones. The first zones to be inspected are selected immediately after disarmament has begun. After a certain time period has elapsed, other zones are duly selected for inspection, while those already chosen remain open to inspection. The whole process is timed so that inspection will be complete only when the disarmament process is complete; inspection thus becomes more extensive with comprehensive disarmament. Eight steps are outlined for the implementation of progressive/zonal inspection:

(1) the division of territory into zones and the declaration of arms, force levels, and activities;

(2) the selection of the first zones for inspection;
(3) the declaration of the location of activities within those zones by the host country;
(4) arrangements are made to prevent the movement of arms or troops;
(5) aerial and mobile inspections are conducted;
(6) once an area has been inspected it remains open to future inspections;
(7) the whole process is repeated when new zones are selected; and
(8) after each round of zonal inspections has been conducted, arms levels are once again declared by the respective nations.

Proposal Abstract E9(A60)

1. **Arms Control Problem:**
Nuclear weapons - ballistic missiles
- manned aircraft

2. **Verification Type:**
(a) On-site inspection - progressive/zonal
- control posts
(b) Remote sensors - aerial

3. **Source:**
Kissinger, H.A. "Arms Control, Inspection and Surprise Attack". Foreign Affairs 38, no, 4 (July 1960): 557-575.

4. **Summary:**
Each country with nuclear weapons would designate regions where it would agree to station no retaliatory weapons, and another group of areas in which only a certain number would be permitted. The areas stripped of retaliatory weapons would be open to unlimited inspection. This would be "negative evidence" inspection, which seeks to verify the absence of retaliatory weapons.

In the regions containing retaliatory weapons, "inventory" inspection would be carried out. That is, at some agreed interval, perhaps twice a year, inspectors would have free access to determine the strength of available forces. These inspectors would be barred at all other times. During the periods of inventory, the retaliatory force would have to be stationary, and this could be monitored through an adequate combination of ground and aerial inspection. These forces could be mobile at all other times. The system would not necessarily create excessive vulnerability during inventory periods when the precise location of opposing forces is known. That is, if land-based retaliatory forces were placed in several different areas separated by territory in which uncontrolled inspection were permitted, and inventories in each area were taken at different times, the retaliatory force would continue to be mobile in some regions while it is being counted in others. Unlimited inspection in the territory separating these areas could detect the shifting of weapons from one region to another. Inspectors could be stationed at all access points to armed areas, thereby preventing substantial illegal build-ups.

If armed areas were kept away from industrial areas, production of weapons could be easily and constantly monitored by inspectors in the unarmed areas.

If all ports and harbours were included in regions of unlimited inspection, a check on new construction would be achieved. An inventory on the total force could probably be obtained in this way too, since all ships must return to port at some time.

To ensure that aircraft are effectively counted and that illegal shifting of aircraft does not occur, the whole inventory process should begin with a count of all aircraft in all regions. At the beginning of the inventory, all planes would be grounded and inspection teams would move into the airfields. After the planes are counted, the inventory of missiles would proceed region by region. To prevent the airlifting of missiles out of areas where an inventory is about to take place, the inspection teams would remain at the airfields until the inventory in all regions was completed.

Proposal Abstract E10(A61)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   - sampling
   (b) Remote sensors - aerial
   (c) Records monitoring - plant

3. **Source:**
   Wiesner, J.B. "Inspection for Disarmament". In Arms Control: Issues for the Public, pp. 127-131. Edited by L. Henkin. Englewood Cliffs, New Jersey: Prentice-Hall, 1961.

4. **Summary:**
   Assuming the existence of an agreement severely limiting the number of ballistic missiles a nation may maintain, this proposal envisages a system to verify that the specified reduction takes place and that there are no clandestine increases later.

   The control system would require each party to inform the inspecting authority of how many missiles it had manufactured, how many it was now giving up to reduce to the required levels and where the remaining missiles are located.

   In a phased program, the process of determining the veracity of the submitted information would be controlled. On-site inspection of production facilities and their records, interrogation of personnel engaged in missile development and production would serve to confirm the declaration of past missile production. Aerial and random ground inspection (phased, by area) would verify present levels and would help to uncover clandestine stockpiles. Sampling techniques would make 100% assurance of compliance unnecessary.

 E11(A62)

Proposal Abstract E11(A62)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - missile tests

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   - control posts
   (b) Remote sensors - aerial
   (c) Non-physical/psychological inspection

3. **Source:**
   Etzioni, A. The Hard Way to Peace: A New Strategy. New York: Collier, 1962.

4. **Summary:**

This proposal envisages an agreement that would have national territories subject to disarmament divided into two classifications, those containing nuclear weapons and those devoid of such weapons. The areas should be large enough that an adversary cannot pinpoint strategic targets like missile silos. Non-nuclear areas would then be divided into 10 zones, one of which would be disarmed and opened to on-site inspection each year. After 10 years, the whole country, excepting the nuclear areas, would have been disarmed and inspected.

The author proposes three measures that could be taken to defuse fears of the intrusiveness of this proposal.

Inspectors would:

(1) take vacations outside the country they are inspecting,
(2) be under orders not to fraternize with nationals of the country in which they are stationed, and
(3) live in isolated quarters or in large cities accustomed to foreigners.

Finally, in the opinion of the author, the monitoring of port facilities requires special measures. He proposes that inspection ships should be posted at the entrance of ports and that inspection towers equipped with searchlights be established at the centre of each harbour.

Once non-nuclear disarmament was complete, the disarmed areas would be inspected *in toto* by both ground and air inspection teams to ensure that the weapons stationed in nuclear zones were not being transferred to the disarmed zones. As soon as this is done, each party to the agreement possessing nuclear weapons would declare its inventory of nuclear weapons and delivery systems and would install consistent serial numbers of all weapons. Compliance with the commitment to carry out the serial number procedure would be verified initially by national intelligence means and by "citizen supervision". The author suggests that it would be desirable for

inspected nations to permit random checks of the serialization by other countries. Violation of the serialization commitment would be considered a serious infraction of the agreement. Once the inventory was validated, weapons would be destroyed on a neutral territory, or converted to peaceful uses by the United Nations. The accompanying ban on missile tests would be monitored from stations outside the country and from stations located in the de-militarized zones.

The process would proceed until each country had just one zone armed with nuclear weapons. The defusing of these weapons could be deferred until such time as the parties considered these safeguards to be no longer necessary. Upon total disarmament, unlimited right of inspection would be initiated to prevent re-arming by dissenting groups.

Proposal Abstract E12(A65)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - manned aircraft
   - missile tests

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   (b) International exchange of information - declarations

3. **Source:**
   Committee on Strategic Delivery Vehicles. Woods Hole Summer Study, 1962. "Verification of Reductions in the Number of Strategic Delivery Vehicles". In Security in Disarmament, pp. 50-68. Edited by R.J. Barnet and R.A. Falk. Princeton, New Jersey: Princeton University Press, 1965.

4. **Summary:**

The focus of this proposal is on the verification of an agreement reducing the number of strategic delivery vehicles, the reductions to be phased in six month increments over six years. The first step involves an inventory declaration of all strategic delivery vehicles as well as facilities concerned with their production and testing. During the first half of the process inspectors would observe the destruction of delivery vehicles and would inspect all declared production facilities. The number of inspectors would be limited initially and gradually increased as their verification duties were extended. This would serve to generate confidence in inspection as a verification technique.

The inspectorate would be allowed a limited number of inspections (say 100) per year for selected facilities, in addition to continuous monitoring of declared production facilities and of test activities associated with related peaceful programs. The inspections would be pre-emptive and would not require presentation of supporting evidence. The inspection visits to industrial facilities might consist of tours through the selected facilities and interviews with plant personnel, with no monitoring of records, blueprint examination or hardware testing. A selective monitoring of activities of professional personnel, especially those presently associated with aircraft and missile program could be undertaken.

The program would include occasional inspection of sites suspected of containing hidden stockpiles, and would cover observation of defensive measures such as air-defence, anti-missile defence and anti-submarine systems.

As a component of the system, a missile test ban might be verified by pre-launch inspections designed to reveal the purpose of each booster test and by employment of radar nets capable of detecting launchings that have not been reported.

Proposal Abstract E13(G79)

1. **Arms Control Problem:**
   Chemical weapons - destruction of facilities
   - destruction of stocks
   - production
   - stockpiling

2. **Verification Type:**
   (a) On-site inspection - progressive/zonal
   (b) Complaints procedure - consultative commission
   (c) International control organization

3. **Source:**
   Spain. CD/PV.42, 17 July 1979.
   See also: CD/PV.88, 1 July 1980.

4. **Summary:**
   Spain in PV.42 suggests that there is a need for groups of technical experts which could provide extensive technical advice. These would be independent of any bodies of a political nature which might be established. All states should have access to that body without discrimination and there should be no regime enabling some states to block measures designed to ensure prompt verification.

   In PV.88 the Spanish representative stated that any advisory committee set up in the context of a verification system would have to have wide powers. Because of the disparity in technological capabilities between states, the effectiveness of national means of verification should not be over-estimated. The main burden of verification should be borne by international means. The capabilities of an international body would be greatly enhanced if states in possession of advanced capabilities would cooperate with that body.

   On-site inspections are needed, however, In this regard, a gradual process of delimiting critical zones which could be subject to on-site verification would be possible. These zones could be established initially in light of information circulated in the media and gradually extended to sectors with large-scale chemical industry complexes. This procedure could be negotiated within the framework of some international machinery that might perhaps be established.

CHAPTER F

CONTROL POSTS

Control posts frequently constitute an element in other types of inspection systems. Essentially a control post is a focal point for an inspection team. It can be fixed if the team is responsible for monitoring equipment in the neighbourhood in which it is located, or mobile if the teams's function is to monitor a military formation which is itself mobile. A common proposal is to have control posts to monitor military traffic at such locations as transportation centres, airfields, railway stations, main road junctions and ports. Such monitoring, it is argued, should provide warning of impending aggression by detecting any unusual flow or concentration of military power or weapons production.

Information can be obtained at a control post by direct observation as well as with short- and medium-range sensors. To be effective, control posts require secure communication to an information centre so that the information collected can be properly evaluated.

Control posts appear to be mainly of use in a potential confrontation situation; where troops are deployed and maintained in some degree of readiness. The two proposals included in this chapter relate specifically to the NATO-Warsaw Pact confrontation in Europe, but the method would be equally applicable to other areas of potential hostilities.

Proposal Abstract F1(A64)

1. **Arms Control Problem:**
Regional arms control - demilitarization
- Europe

2. **Verification Type:**
On-site inspection - control posts
- progressive/zonal

3. **Source:**
Holst, J.J. "Fixed Control Posts and European Stability". Disarmament and Arms Control 2 (1964): 262-297.

4. **Summary:**

This proposal suggests that fixed control posts be established on the territory of the party being monitored. These posts would report to evaluation centres located within the inspecting party's territory. A fixed control post is defined in general terms by the author as a post whose area of access is limited to approximately four square miles. Such an area would cover the most important part of a harbour, a railway junction, an airfield or fixed military installations such as a rocket base, a naval base or a garrison. Further, the posts could in some cases be fixed in relation to moving coordinates; for example, military units. Posts might be deployed at divisional headquarters, and move with these, for instance. The author outlines several possible types of control post, each varying by the degree of access permitted to sensitive objects of control.

The author further proposes that the area to be controlled, Europe for example, be divided into zones. Relatively narrow zones would be established on either side of the border, which would comprise a high-tension zone. Beyond these high tension areas would be established other zones to include less sensitive territory. A third set of zones would cover the rest of the region to be controlled.

The author holds that control posts established in the border zones would be highly susceptible to false alarms. They would also be unable to detect large-scale preparations which would likely take place in the second (middle) zone. Consequently, the largest number of posts should be established in the middle zone where major military preparations would probably occur.

Any missile and bomber threat would likely come from bases contained in the third (outside) zone. Control posts at airfields and missile bases might provide a brief warning time, but as the author notes would probably be too intrusive to be acceptable. Posts in the third zone monitoring conventional build-ups would, however, comprise an important component of the system.

The author notes that this proposal could detect rapid, large scale build-ups and could improve the ability to detect long-term build-ups. It could not provide answers to all conceivable threats nor even to some of the more probable ones (eg. local aggression, border harassment, etc.). Nevertheless, it might provide a means of reassurance in a tense situation.

Proposal Abstract F2(A65)

1. **Arms Control Problem:**
   Regional arms control - demilitarization
   - Europe

2. **Verification Type:**
   On-site inspection - control posts

3. **Source:**
   Windsor, P. "Observation Posts". In <u>First Steps to Disarmament</u>, pp. 85-99. Edited by D.E. Luard. London: Thames and Hudson, 1965.

4. **Summary:**

   This proposal calls for the establishment of static inspection teams (control posts), stationed at three kinds of communications centres in Europe:

   (1) airfields capable of handling heavy transports,
   (2) main roads, and
   (3) railways.

   In Western Europe, roads, highways and airfields would be of special interest while in Eastern Europe, railroads and airfields would be more important. The posts would be manned by members of the opposing Alliance who would be in constant communication with their respective headquarters.

   This system would not necessarily provide better information about general movements and standards of the opposing forces and their equipment than is already afforded by intelligence sources. Rather, its purpose would be "to establish norms of military activity". Warning of attack would come from notice of long-term preparations and large-scale build-ups of troops and equipment. It would give notice of rising tensions and might thereby reduce the risk of miscalculations. Furthermore, it could create a climate conducive to later reduction of armaments and troop levels and perhaps eventually to demilitarization of the zone.

   It is suggested that initially the control posts could be located between the Rhine River and the Polish/Soviet border, the zone to be extended at a later date.

CHAPTER G

RECORDS MONITORING

Records monitoring has been suggested as an acceptable alternative to monitoring or inspecting actual events and processes. While it is accepted that records may suffer from sins of omission, inaccurate reporting or deliberate falsification, there is a belief that the country performing the activities needs accurate records for its own purposes and if it would make these records available to other countries they would be able to form a reasonable picture of the extent and objective of those activities. A variety of records have been suggested as suitable for this purpose. Three basic types can be distinguished:

A) economic records,
B) plant records, and
C) personnel records.

A. Economic Records Monitoring

This technique, which is most frequently discussed in the context of a ban on CW production, can be distinguished from plant records monitoring mainly by its focus on general production processes, on an industry-wide level. It involves collecting and analyzing economic data on production, consumption, and trade of either:

(1) certain critical or unique substances necessary to the production of a weapon; or
(2) all intermediates necessary for production when a unique component cannot be found.

The objective is to detect any changes or inconsistencies in the production processes which may indicate a violation of an obligation assumed under an arms control agreement.

The technique can focus on two types of data. It can involve analysis of data acquired from existing sources of information published openly by national governments, in which case, it is tantamount to a literature survey (see Chapter L). Or it can involve analysis of data received under an international exchange of information deliberately undertaken to provide data for verification purposes (see Chapter M). A third possibility is, of course, some combination of these two approaches.

The use of information from open sources may involve problems since the quality and credibility of the data can vary from country to country. Many states may simply lack the capacity to generate accurate and dependable data of use for verification. Some states may have inhibitions about disclosing a great deal of information, hence any they do publish may be scant and undetailed. Other governments may deliberately falsify published information for motives of their own.

Furthermore, it is probable that there exists no standardized approach to measuring the economic activities concerned. Almost certainly methods of reporting statistics and other information will vary considerably between countries, especially in the scope and detail of the data.

Assuming that the above problems are worked out, economic records monitoring must still face its ultimate test - how effective it is in detecting violations. Here three problems must be considered. First,

there is an important problem regarding the time lag involved in using the technique. Collecting and organizing data of this nature takes considerable time. Consequently, the reporting of the data will lag behind the occurrence of the events which it is intended to detect. In addition, there will be further delay as this published data is analyzed. It is not unlikely therefore that the overall time lag could amount to two or three years. This is a serious problem since the speed of detection can be crucial to the credibility of a verification technique. Compounding the problem of delay even further is length of time necessary to build a counter capability to that of the violator.

Second, economic records monitoring may simply be too insensitive to detect any but the most massive violations because of the nature of the data which is involved. It should be pointed out, however, when weighing this problem that relatively small violations may have little negative effect on the national security of innocent parties. This reasoning, unfortunately, comes up against the threat posed by deliberate prolonged evasion. Because of the technique's insensitivity, particularly when large amounts of substances are being monitored, a violator could, with reasonable confidence of avoiding detection, merely protract his diversion of substances over a long period of time.

A third problem concerns the magnitude of the task allotted records monitoring. It is clear that large amounts of data will have to be analyzed and a complex model developed for interpreting this information. Neither may be easily accomplished. Consequently, considerable investment in terms of money, manpower and other resources may be needed.

B. Plant Records Monitoring

This technique has been suggested most frequently in the context of a CW production ban and has been incorporated into the IAEA safeguards system for monitoring nuclear materials. The abstracts in Chapter D, "IAEA Safeguards" cover the latter type of plant records monitoring in detail.

Unlike the more general economic records monitoring, this technique almost by definition involves some intrusion into the affairs of the country or company concerned. In theory, plant accounting and operating records might be exchanged on request so that on-site inspection would not be necessary, but in practice many countries would prefer to have some confirmation of the credibility of the data by inspection. It should be noted that the existing IAEA safeguard system uses inspectors to ensure the credibility of plant records.

A further problem is the possibility that commercial and perhaps military secrets about technical processes and industrial capabilities might be gained from detailed analysis of the records provided and from any inspections that might be involved. It should be possible to overcome this, as appears to have been done with regard to IAEA activities, but the possibility may make some countries reluctant to accept records monitoring. Plant records monitoring could be undertaken by individual participating countries or it could be assigned to an international body like the IAEA.

C. Personnel Records Monitoring

Monitoring of the whereabouts of personnel associated with weapons research and production may provide valuable information regarding the status of weapons programs. The idea is simple: if one can ascertain the location and assignment of experts in various fields, it becomes possible to verify whether restricted programs have been halted. If a very accurate account can be kept of personnel, it should even be possible to detect clandestine weapons production.

Various methods exist for gathering the relevant information. Voluntary declarations regarding personnel constitutes the most direct and perhaps the least reliable method. Of course, as long as declarations can be cross-checked with information gathered from other sources this method could be effective. Sampling techniques, perhaps using interviews or random telephone calls, may offer an effective means of verifying the veracity of declarations. Checks may be conducted periodically or on a once-only basis. The former is probably a superior method.

It is evident that personnel monitoring can be employed in verifying both bilateral and multilateral arms control agreements. In the latter case, international control over the personnel monitoring system would be indicated, while in the former case, either national or international control would be possible. National control would amount to a trade of data. Presumably means of verifying the veracity of declarations would be established in either case.

A further issue relates to the human rights of the personnel involved. A requirement that they should continuously account for all their activities could well be regarded as an invasion of privacy.

Proposal Abstract G1(A63)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Records monitoring - economic
   - plant
   - sampling

   (b) Literature survey - budgetary analysis
   (c) On-site inspection - selective
   - sampling

3. **Source:**
   Barnstein, Morris. "Inspection of Economic Records as an Arms Control Technique". Journal of Conflict Resolution 7 (1963): 404-412.

4. **Summary:**
The paper examines the nature, utility and limitations of inspection of economic records as a verification technique. The term "economic records" as used here is broad and includes records:

(1) relating to all sectors of economic activity,
(2) expressed in physical or monetary terms,
(3) pertaining to various levels of economic organization,
(4) available at centralized records centers or at individual records keeping units, and
(5) published and non-published.

Essentially records monitoring consists of locating pertinent records and verifying their authenticity. Consistency checks by highly qualified experts are the heart of the method. These involve checking the accuracy of reported information against appropriate related data to determine consistency. The reliability of such tests depends upon the access of inspectors (measured in quantity, variety and degree of detail of records) and the qualifications of the inspectors. It is important to emphasize the need to examine past records in these consistency tests. This enables the inspectors to gain the necessary perspective for assessing current records and it increases the difficulties of falsifying records.

Records monitoring could be useful for discovering clandestine production in undeclared facilities as well as declared ones. It is clear, however, that the technique alone is insufficient. To conduct valid consistency tests it would be necessary to employ physical on-site inspections on a random basis to ensure the authenticity of selected records. On-site inspection and other verification techniques would also be used to follow-up any evidence of a violation revealed by records monitoring. There is a similarity between records monitoring and other verification techniques. While records monitoring can not completely substitute for other methods, it can, for example, reduce the amount of on-site inspection which otherwise would be necessary.

Three problems with records monitoring are identified. First, there may be problems in the availability of records, such as whether they are kept at all, where they are located and what form they take. A preliminary examination of records-keeping practices in the USSR and the US leads the author to believe that it would not be technically difficult to design a records monitoring program for both. He discusses several similarities and several differences in the practices of the two countries which would affect records monitoring. It would be essential, however, that, in addition to existing records in both countries, some special records would have to be maintained for the purpose of verification. It might also be desirable to standardize records-keeping procedures between countries.

To avoid being overwhelmed by detail the records inspectorate would have to focus on selected records. To this end, it is essential to identify critical items in the production of various weapons, upon which the inspectorate could concentrate its records monitoring activities. Another reason for limiting the extent of records monitoring activities is that it would reduce the amount of access required by the inspectorate and thereby perhaps increase the methods' political acceptability.

The author suggests the following records monitoring program:

(1) regular and detailed monitoring of selected key records,
(2) random sample monitoring of selected other records,
(3) random sample on-site inspection in confirm the accuracy of records, and
(4) follow-up on-site inspections to investigate any suspected violations revealed by records monitoring.

The author points out the lack of satisfactory estimates concerning the reliability of the method and its cost. He recommends further research along five lines to provide this information.

Proposal Abstract G2(A63)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Records monitoring - personnel
   (b) Literature survey
   (c) On-site inspection - general
   - sampling
   (d) Remote sensors

3. **Source:**
   Bowen, Russel J. "Soviet Research and Development: Some Implications for Arms Control Inspection". Journal of Conflict Resolution 7 (1963): 426-448.

4. **Summary:**
   The author points out the large effort that would be needed to verify restrictions on military research and development using a general on-site inspection system, even one based on random sampling. Physical inspection of all possible research and development facilities should therefore not be relied upon. More useful would be keeping track of Soviet scientists and technicians. Several foci in the Soviet research and development community for such monitoring of personnel are suggested. Checking the use of Soviet information centres might perhaps be of some use also, as might media analysis. Finally, the author suggests remote sensing of test areas.

Proposal Abstract G3(A65)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Records monitoring - plant

3. **Source:**
   Unclassified Summary: Validation of Records of Production: Final Report. Report to United States Arms Control and Disarmament Agency. Fullerton California: Hughes Aircraft Company, December 1965.

4. **Summary:**

Given the possibility that the Soviet Union might find an exchange of production records more acceptable than other verification methods, together with the possibility that production records could provide an adequate means for verifying existing stockpiles of armaments, this report summarizes research into the feasibility of falsifying production records and the feasibility of discovering such falsifications. Examination of actual records for several production processes at the manufacturing enterprise level was undertaken as part of this study. It was assumed that the records would be inspected by adversary personnel, not international agency staff, and that there were no limitations on access to production records.

It is essential that original records, not copies, be made available in the form in which they have been stored. The method of detecting falsification which was developed consists of four kinds of checks:

(1) Checks having reference to the administrative context of the plant,
(2) Checks of the over-all activity of the enterprise,
(3) Checks of the fundamental relation between input and output, and
(4) Checks on the continuity of the enterprise.

The report also catalogues hiding techniques and the efficacy of the above method in detecting such evasion. It concludes that a method of detecting falsification of production records merits serious attention as a technically promising inspection technique that could make significant contributions to verifying existing armaments stockpiles.

Proposal Abstract G4(A75)

1. **Arms Control Problem:**
Chemical weapons - destruction of stocks
- stockpiles

2. **Verification Type:**
(a) Records monitoring - economic
- plant
- sampling
(b) On-site inspection - selective

3. **Source:**
Roberts, R.E. and C.A. Romine. "The Use of Records in the Verification of CW Stockpile Destruction". In Stockholm International Peace Research Institute, Chemical Disarmament: New Weapons for Old, pp.114-124. New York: Humanities Press, 1975.

4. **Summary:**
In order to ascertain whether all of a country's stockpile of CWs had been destroyed pursuant to a CW Treaty the authors suggest that records on all CW agents and munitions produced during the last 35 years be provided for verification purposes. Analysis of these records would permit the derivation of reasonably accurate estimates of past production which could be compared with the quantities destroyed.

If complete access to records about stockpiles were provided to inspectors they could derive as complete an estimate of the stockpile as the inspected nation. But it is unlikely that such full access will be provided.

To determine what and how much of each CW is in the stockpile requires:

(1) determination of what is in the stockpile when the agents are destroyed which in turn requires information reflecting all past entries and exists from the stockpile,
(2) a continuous monitoring of entries and exits during the destruction phase,
(3) a ban or controls on new production or imports of CWs during the destruction phase, and
(4) some means of dealing with the special problems posed by dual-purpose and binary agents.

Ensuring that what is actually destroyed is the CW claimed can only be done by physical access at the destruction site. Samples of the agent must be taken and the total quantity being destroyed must be measured. This can be accomplished by the use of inspectors at the destruction site or by shipping the agents to an international destruction site. While provision of records will not serve to ensure that the specific agent claimed is actually being destroyed, some information given at this stage will reduce the intrusiveness needed to verify that the whole stockpile has been destroyed (see below).

Historical records involve some problem from the verification point of view:

(1) Were the records accurate when made? Record accuracy can suffer during the start-up phase and during crises. There is also the practice of some plant managers adjusting statistics to conform with imposed quotas.
(2) Were all aspects of the acquisition and consumption of the stockpile covered in the original records system?
(3) Have all records been retained?

Evasion possibilities in regard to historical records are limited. Counterfeiting original records, because of the interlocking nature of records system, would require an extensive effort. If original documents are provided, tests of the paper's age could be useful. Withholding certain historical records would also be difficult because of the interlocking aspect. In contrast to historical records, falsifying current records would be much easier.

Establishing the magnitude of the stockpile would require records which were mutually supporting and interlocked on the following activities:

(1) production,
(2) importation,
(3) transportation,
(4) stockpiling,
(5) exportation,
(6) consumption, and
(7) destruction.

There is a vast number of records which can be drawn on to provide this information some of which the paper lists. The intrusiveness of the verification system could be reduced by judiciously selecting the set of records to be examined.

The interlocking of the record system is a key feature of the verification system proposed. Records interlock in at least five dimensions:

(1) Summarization. This involves source documents which are summarized in journal or ledger entries.
(2) Inter-enterprise. These are generated when a commodity moves from one site to another.
(3) Supporting. These arise when two different types of documents are generated by the same event.
(4) Hierarchical. These link different levels in the organization's chain of command.
(5) Chronological. These link one time period with another.

The paper proposes two verification strategies. The first is based upon a determination of stockpile composition and magnitude prior to actual destruction of the CWs. Five levels of intrusiveness are postulated and summarized in a figure presented in the paper. For three of these levels, intrusiveness and costs of the verification system would be great.

The alternative approach favoured by the authors is to rely on information supplied during the destruction phase to reduce the needs for other information. If data on the nature of the agents, the

quantity in the lot, where it was produced, where it was stockpiled and when it was produced was obtained during destruction and validated as far as possible by inspectors, it would permit the creation of a validated data base containing most of the elements of the information describing a national stockpile without any penetration of the national records. After destruction was completed the verification team could request limited access to selected parts of the national records to verify the accumulated data. Sample validation of this data base capitalizing on several forms of interlocking might suffice.

 G5(G70)

Proposal Abstract G5(G70)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   Records monitoring - economic
   - plant

3. **Source:**
   Japan. "Working paper on the question of verification in connection with the prohibition of chemical and biological weapons". CCD/288, 20 April 1970.
   See also: - "Working paper on the question of the prohibition of chemical weapons". CCD/301, 8 August 1970.
   - "Working paper containing remarks of Professor Shunishi Yamada, the University of Tokyo, concerning the question of verification on the prohibition of chemical weapons, presented at the informal meeting on 7 July 1971". CCD/344, 24 August 1971.

4. **Summary:**
   Certain precursors of raw materials can be used both to produce CWs or non-military chemical compounds. It should be possible to determine whether these materials are being used for production of chemical weapons if one can trace the flow of such materials in each state by checking at certain points the quantities produced, imported, exported, and consumed.

   In CCD/301 Japan suggests that it would be desirable to establish a reporting system for statistics of certain chemical substances perferably on a factory level. Such data could be used to support a complaint. It would, however, be impractical to report on all chemical substances; therefore it has been suggested that a lethal dose criteria be used to determine what substances should be considered. Amongst this group of substances those like nerve gases with no peaceful uses would be totally banned and hence need not be reported. Seven substances are listed that are intermediates in the production of both nerve agents and non-military organophosphorus compounds, for which data should be reported.

   In CCD/344 Japan points out that in compilation of any statistics of the above kind it would be imperative to reduce the extent of statistical error as much as possible in order to decrease the likelihood of diversions.

Proposal Abstract G6(G70)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   Records monitoring - economic

3. **Source:**
   United States. "Working paper on economic data monitoring as a means of verifying compliance with a ban on chemical weapons". CCD/311, 25 August 1970.

4. **Summary:**

The paper is based on research by the Arms Control and Disarmament Agency. It deals with the potential for "economic monitoring" of a ban on production and stockpiling of nerve gases, using the US's economy as a model.

Economic monitoring would aim at identifying changes or inconsistencies in economic data series that could indicate the development of a CW production capability. The analysis might proceed as follows:

First, a prohibited group of chemicals is defined. In the case of nerve gases, a common molecular structure model could be used to this end so as to reduce the number of nerve agents that must be considered from a theoretically immense number to only several thousand. About 90 component materials (raw materials and intermediates) are used to manufacture these agents. Because there is low "commonality" amongst these materials (save for elemental phosphorus, a widely used substance) the economic monitoring system would have to consider all 90 substances simultaneously.

A prospective violator could obtain the component materials for agent production by:

(1) increasing its own production of the required materials,
(2) diverting from existing uses or stockpiles,
(3) importing, or
(4) some combination of the above.

Of these, increasing one's own production or making a diversion from existing stockpiles are likely to be most attractive to a violator.

For statistical monitoring to be of use, the pattern of production and consumption of the materials must be "visible". Visibility is affected by the quantity of agent to be produced, the ability to provide materials from indigenous production, the complexity of the economy and the amount, quality, precision and timeliness of the data supplied.

The paper points to a number of weaknesses in the method of economic monitoring and concludes that the technique could be of ancillary use, but alone would not provide an answer to the verification problem. It might serve as a precursor, guide, support and focussing technique, but not as a substitute for direct technical on-site inspection.

Proposal Abstract G7(G71)

1. **Arms Control Problem:**
Chemical weapons - production

2. **Verification Type:**
Records monitoring - economic

3. **Source:**
Italy, "Working paper on some problems concerning the prohibition of chemical weapons". CCD/335, 8 July 1971.
See also: - "Working paper on identification and classification of chemical warfare agents and on some aspects of the problem of verification". CCD/373, 29 June 1972.

4. **Summary:**
Use of economic records monitoring to detect percentage variations of organophosphorus substances arising from any diversion of these substances to production of nerve gases is feasible under certain conditions. Monitoring of raw materials (i.e. phosphorus) would be possible in countries where production of phosphorus is small. The less the initial amount of raw materials available the more significant (and detectable) will be the percentage variation due to diversion. A similar pattern can be expected for intermediate substances. It is acknowledged, however, that for states where supplies of raw and intermediate materials are very large, the usefulness of percentage variation decreases. Nevertheless, the technique is still applicable to the majority of states. It would be useful as a first step in identifying signs of suspicious activity.

Employment of the technique necessitates the collection and processing by powerful computers of large amounts of statistical data for the construction of complex models. A number of models will have to be tested and improved until a definitive one is worked out.

In CCD/373, Italy elaborates on these ideas. It defines two types of chemical agents to be banned: single purpose and dual purpose agents. The former, in most cases, are based on the use of "critical" raw materials, that is, materials which are abundant but whose sources are limited in number and location. Economic records monitoring of production of the these single purpose agents would be easier "as the proportions of raw materials required for military use are greater than the average amounts used for civilian purposes in a given state, if that state were to decide to build up a militarily useful chemical stockpile". Accordingly, this type of control would be applicable at least for verification of suspected violations, in a number of states; but it would be useless in states which are major producers and consumers of such raw materials.

Verification of dual purpose agents would be easier. If a state wishes to build a military arsenal from such substances it would have to divert large amounts of them would have a significant impact on the

average amount produced for large scale civilian use. Under these circumstances, economic monitoring would be simplier. But the industrial and economic data would have to be sufficiently ample and "analytical" to reveal meaningful deviations from either the average or forecast indices.

Proposal Abstract G8(A73)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   (a) Records monitoring - economic
   - plant

   (b) National self-supervision
   (c) On-site inspection - selective
   (d) Short-range sensors - sampling
   - seals
   - monitoring devices

3. **Source:**
   Stockholm International Peace Research Institute. Chemical Disarmament: Some Problems of Verification. Stockholm: Almqvist & Wiksell, 1973, pp. 24-25, and 31-32.

4. **Summary:**

This proposal calls for broad rights of on-site inspection of chemical production facilities. The most useful method appears to be visits to chemical plants by inspectors from a national control organ, to become acquainted with all the products which are being produced, in all stages of the production process. Differentiation between chemical agents produced for warfare and those produced for peaceful uses is possible by studying the safety measures applied in the factory.

The proposal suggests that before deciding to visit a plant, analyses of the contents of possible additives in waste waters, waste gases and in the soil around the plant building should be undertaken. Where the presence of suspect compounds was established, an inspection of the plant concerned would be indicated. The proposal suggests, further, that upon implementation of a ban on the production of militarily significant chemical agents, national control agencies should verify the closure of the plants concerned and their conversion to the production of compounds for peaceful uses.

In the case of dual-purpose products, the verification system would deal primarily with statistical accounting of production and consumption. Accounting for the derivative products of certain chemical processes would be especially useful. Inspection of plant records and becoming acquainted with the processes of the plant would provide added assurance as to the accuracy of all relevant data.

It is further suggested that in cases where on-site inspection of individual enterprises is not feasible, remote monitoring devices, sealed and accessible only to those authorized by the national control agency, should be employed.

It is also recommended that an analysis of the statistical data accumulated to verify the ban on production of CW agents be made at least once a year, and in some cases, more frequently.

With regard to the national control organ, it is essential that the agency be able to fulfill its functions under the unique conditions of the country concerned. The agency must be an arm of the central government though preferably an independent body reporting directly to the head-of-state. Such agencies exist already in many states. The personnel of the agency could include representative of government, press, trade union, scientific and technical societies, national academies of science and other organizations, as well as specialists and technicians.

In a paper* incorporated as an appendix in this source, a detailed proposal for a chemical control system (CCS) is made. The CCS is envisaged as a national control organ which would:

> ... monitor all economic and industrial activities connected with dual purpose agents and with essential ingredients required in the production of single purpose agents ... To accomplish this task, the industrial enterprises which produce, transport or use controlled materials are required to maintain internal records and prepare periodic reports of all relevant activities. To ensure the accuracy of these industrial level reports, a number of checks and balances have been incorporated into the system, such as registration of all industrial establishments, authorization of production and use quantities, reports from two or more independent sources on all material movement, and independent audits of the records and material control procedures at production plants. The reports submitted by an individual plant are subject to verification against reports from customers, suppliers and transportation companies with which it does business.

The administration and operation of the CCS is divided between two organizational levels - National Control Agencies and industry. The National Control Agency is responsible for the operation and control of the system within its country's borders and must provide verification to other National Agencies that industrial establishments have complied with all provisions of the CCS. The industrial level is required to follow authorized material handling procedures, maintain minimum accounting records, and report to the National Control Agency (pp. 61-62). A general list of functions performed by each level is shown in the table below**. Detailed descriptions of the individual components of this system are provided in the source.

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* Pittaway, A.R., <u>et al</u>. "Paper prepared for discussion of the working group meeting on 16-18 December 1972". In <u>Ibid</u>., pp. 51-130.

** <u>Ibid</u>., Table 1, p.62.

FUNCTIONS OF THE TWO ORGANIZATIONAL LEVELS WITHIN THE CCS

LEVELS	Functions
National Control Agency	1. Exercise primary legal, administrative and technical controls 2. License all production, use and transportation of controlled materials 3. License, control and inspect international trade in controlled materials 4. Establish national records for each controlled material and plant 5. Verify accuracy of industrial level reports 6. Audit/inspect industrial records and operations 7. Report activity in controlled materials, nationally and internationally
Industry	1. Furnish data to National Control Agency pertinent to controlled material 2. Follow material control procedures as directed by national government 3. Maintain records as directed by national government 4. Respond to challenge audit/inspections by National Control Agency

Proposal Abstract G9(A74)

1. Arms Control Problem:
   Chemical weapons - production
   - stockpiling
   - destruction of stocks
   - binary agents

2. Verification Type:
   (a) Records monitoring - economic
   - plant
   (b) International exchange of information
   (c) Remote sensors

3. Source:
   Robinson, Julian P. The United States Binary Nerve Gas Programme: National and International Implications. Sussex: Institute for the Study of International Organization, 1974. ISIO Monographs. 1st series, no. 10.

4. Summary:

In evaluating the US Department of Defense's decision to modernize its nerve gas stockpile with binary nerve gas weapons, the author considers the implications of the decision for arms control and disarmament. In contrast with the US negotiating position that verification procedures for a chemical disarmament agreement "would be acceptable if they provided no less a degree of security than the current nerve gas deterrent" (p. 28), Robinson argues that only minimal verification procedures are necessary because the nerve gas deterrent does not enhance security at all. A retaliatory capability with nerve gas would be useless since the attacker would shield his troops from their own gas. As a result, "anything having a greater-than-zero chance [of detecting illicit production] ought to be acceptable, provided destruction of existing stockpiles could be assured to an appropriate degree" (p. 29). While binary nerve weapons pose special verification problems which cannot be solved by extraterritorial surveillance, the limited verification requirements just mentioned can be met by economic data monitoring based on phosphorus accountancy (see abstract G8(A73)). However, different national perspectives on such a proposal would have to be reconciled before it could be implemented. The US prefers access to accounting records on a challenge basis by an international group whereas the USSR believes that internal auditing after a challenge would suffice.

Proposal Abstract G10(G74)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   (a) Records monitoring - economic
   (b) On-site inspection - selective
   - obligatory
   (c) Short-range sensors - sampling
   - monitoring devices
   (d) National self-supervision
   (e) International control organization

3. **Source:**
   United States. "Working paper on diversion of commercial chemicals to weapons". CCD/437, 16 July 1974.
   See also: CCD/311, 25 August 1970 (Abstract G6(G70)).

4. **Summary:**

This paper is concerned with the establishment of a control system to monitor the production, transportation and use of all phosphorus compounds which can be used in the production of a nerve gas. It is a follow-on paper to CCD/311. The objective of such a system would be to ensure that all consumption of divertible phosphorus compounds could be traced to legitimate activities. To accomplish this task, the industrial enterprises which handle these materials would be required to maintain detailed internal records and to prepare periodic report on all relevant activities. In addition, all transfers between plants would have to be documented. Checks would be incorporated into the system to ensure accuracy of these industrial level reports.

The administration and operation of the control system could be divided among several levels. First, industrial enterprises would be required to follow authorized material handling procedures, maintain adequate records and report to the national control agency. Second, a national body would have primary responsibility for applying controls to enterprises within its jurisdiction. It would report to the international control agency. Third, an international agency would oversee the entire system, analyze and audit reports from each national agency and monitor international trade in controlled materials.

There are three basic verification techniques which can be used by the control agencies to determine the accuracy of the reports:
(1) analysis of statistical information in the reports,
(2) examination and analysis of records, and
(3) "technical inspection".

The international body, in order to verify the system's reporting accuracy, would regularly analyze reports of national control agencies and perhaps those of certain enterprises. Periodically, the international agency would audit relevant records of the national agency and in addition would have authority to audit either the national agency's or any enterprise's records if there was a discrepancy.

It would also be necessary to develop a reliable system based on technical inspection to detect false records.

Technical inspection includes:

(1) visits to certain chemical plants,
(2) technical analysis of plant operating data,
(3) analysis of samples of phosphorus-containing chemicals which are in inter-plant transit, and
(4) monitoring of recording devices to provide independent information on plant production rates.

The paper continues by describing two evasion methods. First, phosphorus material could be diverted from within the system or, second it could be obtained from sources outside the system's control. The paper mentions nine possible ways in which the former type of evasion could be accomplished, three of which are possible in the American phosphorus industry. Six ways of evading from outside the system are listed.

This control system differs from that described in CCD/311 primarily by the inclusion of technical inspection. Here, statistical data provide the background for combined use of audit and technical inspection procedures which increase the utility of the statistical data. "Conventional" on-site inspection is not highly effective in this field. Technical inspection combining analysis of plant operating records with conventional records auditing procedures would not require actual presence on-site but would require access to all plant records. Technical inspection methods 3 and 4 above would reveal evasions undetectable by other means, (see the working paper for examples).

For the control system to be an effective deterrent to violations:

(1) the international control agency must have access to individual plant records;
(2) the international agency should be allowed to conduct independent investigations of a plant's records; and
(3) technical inspection should be an integral part of the data validation procedure since a standard records audit is insufficient.

In conclusion the paper claims that the procedures described are not sufficient in themselves to provide adequate assurance of compliance but could play a useful role in conjunction with other verification methods.

Proposal Abstract G11(G85)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   (a) Records monitoring - economic
   (b) On-site inspection - selective
   - challenge
   - sampling

3. **Source:**
   Australia. CD/PV.309, 18 April 1985.

4. **Summary:**

Australia proposes procedures for the verification of non-production of chemical weapons which include: materials accountancy; routine, random inspections of chemical industries; import/export regulations and customs checks; and challenge inspection to clarify ambiguities.

Australia suggests that quantities of chemicals greater than one tonne should be inventoried and monitored. Data recorded would include: total annual production, amount used in the country of origin, purpose of use, nature of end-products and the amount exported and to whom. Chemicals would be monitored throughout their lifetime and the production and use of the chemicals would be subject to routine, random inspection. Super-toxic lethal chemicals, lethal chemicals and key precursors, would be monitored based on a list which would assist inspectors. Monitoring would have to be sufficiently stringent to deter diversion of chemicals from the civil chemical industry to military use. Data collection in a central computer verified by routine random inspection and sampling and, in cases of serious ambiguities, by challenge inspection, would provide effective verification.

Australia suggests that monitoring "non-production" would be preferable to outright bans because bans can be circumvented. Monitoring would also extend to exports to other states if there is a prohibition in the convention on assisting anyone in taking part in banned activities. This process would lead to appropriate measures to deal with violations.

Proposal Abstract G12(G86)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   (a) Records monitoring - economic
   (b) International exchange of information
   (c) On-site inspection - selective
   - challenge

3. **Source:**
   Australia. "Verification of non-production of chemical weapons and their precursors by the civilian chemical industry: Trial inspection of an Australian chemical facility". CD/698, 4 June 1986.

4. **Summary:**

Australia recognized that it would be necessary to monitor the civilian chemical industry to ensure that chemical weapons are not produced or their precursors diverted for purposes in contravention of the convention. The system of monitoring would consist essentially of the collection and exchange of data covering the production, consumption and use of listed chemicals. A process of material accountancy would need to apply throughout the lifetime of such chemicals.

Data describing production, consumption and end use of chemicals whose diversion would pose a high risk should be verified by routine random inspection. Data covering chemicals considered to pose less of a risk should be subject to some sort of "spot-check" to remove substantive doubts that might arise concerning compliance or to provide reassurance to the international community that provisions of the convention are being observed. The criteria for the inspection are that it should be effective, cost-effective and should protect commercial confidentiality.

The Australian Government developed an inspection procedure which would meet these criteria and this procedure was later tested in a "trial inspection" of an Australian chemical facility. This paper sets out the results of that trial inspection.

CHAPTER H

NON-PHYSICAL/PSYCHOLOGICAL INSPECTION

Non-physical/psychological inspection is founded on the idea that it is people who violate arms control agreements, not things. As such it constitutes a novel departure from physical inspection which seeks to directly monitor the objects of agreements, be they missiles, nuclear materials or conventional forces. Non-physical/psychological inspection concentrates on people's knowledge of violation and attempts to devise plans for extracting this knowledge. The approach assumes that a government whose citizens were prepared and able to report their knowledge of violations would be hard pressed to secretly circumvent agreements or otherwise conceal violations.

Such systems differ in terms of the methods they employ and the degree of contact they seek to establish in order to extract information. The lengths to which they go may vary from the use of interviewing techniques to considering the implantation of devices in the brains of certain individuals to ensure their cooperation. Most systems, in fact, combine a number of methods in the hope of covering as great a portion of the population as possible. Since certain people are more likely to have knowledge of violations than others, the techniques employed must be designed to take this into account. Very general and loose methods may be appropriate for the general public, while more intense (and generally more intrusive) methods may be desired for those most likely to have knowledge of violations, such as military scientists and politicians.

Another source of variation within this type of verification concerns the nature of the party responsible for implementing the monitoring system. While most often an international inspectorate is envisaged, in which inspectors would seek individuals with knowledge of violations, some proposals suggest national systems which would utilize a national sense of honour to motivate voluntary reports. While national systems avoid the problem of international intrusion, they are not amenable to establishing confidence on the part of other parties to a treaty. In short, national systems lack high credibility. However, some aspects of national systems, for example, announcements by high officials asking for public support for arms control agreements, can be monitored by non-intrusive means.

Both active and passive systems have been proposed. Under the active mode, inspectors would conduct interrogations and interviews. The passive mode, on the other hand, would work within the framework of a system specially tailored to encourage voluntary disclosures of information. Passive system often provide for rewards and penalties, and seek to establish channels of communication to ensure safety for informants. As mentioned earlier, most systems envisage a combination of these two approaches.

Proposal Abstract H1(A61)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Non-physical/psychological inspection
   (b) International control organization

3. **Source:**
   Bohn, L.C. "Non-Physical Inspection Techniques". In Arms Control, Disarmament and National Security, pp. 347-364. Edited by D.G. Brennan. New York; Braziller, 1961.
   See also: "Non-physical techniques of disarmament inspection". In Preventing World War III: Some Proposals, pp. 20-39. Edited by Quincy Wright, William M. Evan, and Morton Deutsch. New York: Simon and Schuster, 1962.

4. **Summary:**

This proposal departs from the physical inspection approach in which there is a focus on violations themselves as physical phenomena and concentrates instead on knowledge concerning violations. Methods are envisaged that would motivate individuals who learn of violations to bring their knowledge to the attention of an International Control Organization. Such individuals might include guards, scientists, clerks, accountants, explorers, aviators, police, technicians, and perhaps highly placed politicians. Knowledge detection could be approached in both voluntary and involuntary ways.

Voluntary reports might be encouraged in several ways including official government support for the arms control agreement and for public assistance in monitoring compliance. There might be a requirement that governments actively promote popular participation in the verification process. Legal penalties for withholding information, as well as rewards for reporting could be instituted. Safe channels for communicating reports would be required, free of national government interference or intimidation. The whole system could be tested if the International Control Organization periodically introduced "dummy" violations, to see if they were reported.

There is an obvious assumption here that the most likely violations of arms control agreements would require the participation of relatively large numbers of people. In order to counter the argument that a small group might be able to violate an agreement without being detected, it is further proposed that each party to the agreement should draw up a list of perhaps one thousand individuals who would be candidates for closer inspection. Closer inspection would involve the use of sensing devices that measure the psychological reactions of an individual as he is questioned about his

participation in or knowledge of a violation of an arms control agreement. "Lie detectors" are examples of such devices.

In the article included in Preventing World War III, Bohn lists some of the critical questions which must be researched and answered before the utility of the non-physical inspection approach can be determined.

Proposal Abstract H2(A61)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Non-physical/psychological inspection
   (b) International control organization

3. **Source:**
   Wiesner, J.B. "Inspection for Disarmament". In Arms Control: Issues for the Public, pp. 123-126. Edited by L. Henkin. Englewood Cliffs, New Jersey: Prentice-Hall, 1961.

4. **Summary:**
   This proposal seeks to verify an arms control agreement by utilizing the knowledge regarding violations possessed by specific groups of individuals or by the population as a whole. The following methods are suggested:
   (1) The treaty could give the international inspectorate the right to ask any citizen questions concerning possible treaty violations. If desired, heads of state could be excluded without much loss of effectiveness.
   (2) The treaty could legally require all citizens (except possibly heads of state) to answer all relevant questions when interviewed by the inspectorate. It could provide punishment of citizens who refuse to answer relevant questions or who are found guilty of lying to the international inspectorate.
   (3) Substantial rewards (e.g. $100,000 or more, non-taxable) could be provided for citizens who report verifiable violations to the inspectorate.
   (4) Assuming a reliable lie detector could be developed, the treaty could give the inspectorate the right to use such an instrument in their interviews.
   (5) The treaty could make it the duty of each citizen with knowledge of any treaty violations to report it to the international inspectorate. Failure to report could be made punishable.
   (6) The treaty could guarantee to a person reporting a violation that he and his family could obtain sanctuary abroad whenever they so desire.
   (7) There could be an agreement that the leaders of both sides must give such provisions their enthusiastic support on a regular basis through the mass media.

Proposal Abstract H3(A62)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Non-physical/psychological inspection

3. **Source:**
   Gerard, R.W. "Truth Detection". In Preventing World War III: Some Proposals, pp. 52-61. Edited by Quincy Wright. New York: Simon and Schuster, 1962.

4. **Summary:**

The author proposes the key official spokesman of countries be subjected to "truth detection" procedures administered by personnel from an adversary state or the UN. Such procedures could be applied during both private negotiations and public addresses.

"Truth detection", as understood by the author would include use of polygraphs, measurements of respiration, heart rate, skin resistence, etc., to detect truth or falsehoods under questioning. Presumably "... with growing conviction that false statements would be caught up, spokesmen would tell the truth publicly and their hearers would come to have some trust in the truth of these statements".

Proposal Abstract H4(A63)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Non-physical/psychological inspection

3. **Source:**
   Deutsch, K.W. "The Commitment of National Legitimacy Symbols as a Verification Technique". In Weapons Management in World Politics: Proceedings of the International Arms Control Symposium, December 17-20 1962, pp. 454-463. Edited by J.D. Singer. Ann Arbor, Michigan: 1963.

4. **Summary:**
   This proposal is based on the concept of "national legitimacy symbols". The author holds that in every state: "legitimacy ... represents the assurance of continued systems integration and thus is a vital systems requirement, the 'legitimacy system' of any state or society forms one of its most vital - and potentially vulnerable institutions" (p.456).

   The system proposed here and based on this idea of legitimacy is essentially a knowledge detection system. A substantial part of the population would be encouraged to alter their value system such that they would reject any obligation to keep any secret related to national evasion of an arms limitation agreement and would refuse to give even passive support to the concealment of any evasion. The author cites figures indicating that experience in World War II supports confidence in the capacity of populations to cooperate with security inspectors. As well, "public opinion surveys showed that already in the 1950's in a number of Western countries including the United States, between 50 and 80 percent of the respondents expressed their readiness in the event of an arms control agreement to reveal 'national' secrets of arms control evasion to foreign inspectors entitled to the information" (p.460-61). These examples indicate that the development of this attitude would not be too difficult.

   Essentially, the author believes that by the pledging of national legitimacy symbols - perhaps the word "honour" could be substituted here - the process described above would be initiated. The countries involved would commit their highest organs of authority, on the most solemn national occasions of each year, to address direct and varied messages to all the citizens, particularly to scientists, officials, and members of the armed forces, reminding them to their national and personal obligation to comply faithfully with the arms limitations and to report on adherence to the provisions of the agreement. The messages would remind the public in each country of their obligations

to uphold and defend these agreements, not only for the sake of their national honour and their continued ability to trust their own governments and one another, but also for the sake of their own survival, and that of their families, communities and nation. Such addresses could be made for instance, on July 4, New Years Day and on May 30 (Memorial Day) in the United States, and on May 1, November 7 and the New Years Day in the Soviet Union. This process should be incorporated into domestic law by all parties. Presidents, congresses and parliaments could participate in developing this commitment of legitimacy symbols. The mass media and youth clubs could also participate; in fact, all manner of organizations should be encouraged to take part. The author contends that with such broad participation, secret violations of arms control agreements would be nearly impossible.

Proposal Abstract H5(A63)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Non-physical/psychological inspection

3. **Source:**
   McNeil, E.B. "Psychological Inspection". In Weapons Management in World Politics: Proceedings of the International Arms Control Symposium, December 17-20 1962, pp. 124-136. Edited by J.D. Singer. Ann Arbor, Michigan: 1963.

4. **Summary:**

Like other proposals for psychological verification systems, this one is based on the idea that "things" do not violate agreements; people do. The author maintains that several attitudes can be detected by psychological inspection:

(1) proneness to violate,
(2) intent to violate,
(3) guilty knowledge of past violations,
(4) violations not covered by the agreement, and
(5) isolated violations not inspectable by physical means.

The proposal discusses several of the techniques potentially applicable to a psychological verification system including:

(1) intelligence,
(2) questionnaires,
(3) interviews and interrogations,
(4) objective tests,
(5) projective tests,
(6) lie-detection,
(7) hypnosis,
(8) analysis of variations in the nervous system and body chemistry,
(9) psychomimetic drugs (LSD_{25}, etc),
(10) truth serums,
(11) mood transforming drugs,
(12) sensory deprivation,
(13) brainwashing and isolation from a frame of reference, and
(14) electrode implantation.

Admitting that several of these techniques may be excessively intrusive, the author suggests a practical minimum of psychological inspection whereby inspectors would be trained to develop their observation skills much as are clinical psychologists. This would help them to detect suspicious activities and attitudes without excessive intrusion.

Proposal Abstract H6(A63)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Non-physical/psychological inspection
   (b) Literature survey

3. **Source:**
   O'Sullivan, T.C. "Social Inspection". In Weapons Management in World Politics: Proceedings of the International Arms Control Symposium, December 17-20, 1962. Edited by J.D. Singer. Ann Arbor, Michigan: 1963.

4. **Summary:**

The technique proposed here, "social inspection", concentrates on examining the society in which the violation occurs. Information concerning a violation "would be gathered through tapping memories of people, observing their behaviour, analysing organized behaviour, etc" (p.466).

The author suggests four forms of social inspection, varying primarily in the degree of contact:

(1) The most intimate forms are psychological and physiological examination. They might be performed on a small body of the national decision-making elite, who would be aware of any cheating.
(2) The next level involves less intensive personal contact with, and observation of, a broader but still select group who might have participated in any violations or who might be aware of them through professional or personal contacts.
(3) The third level involves observation of organized activities, that is, analysis of social patterns, group behaviour, etc.
(4) Finally, the least intimate form of social inspection involves media analysis, detailed analysis of newpapers and professional journals, public pronouncements, etc.

While recognizing that the techniques needed to apply this system are not sufficiently developed to permit its rapid implementation, the author believes this to be a matter of time and effort.

Both active and passive modes are envisaged for this system. The active mode has been described above. The passive mode would consist of a system of communication between the general public and the disarmament verification organization which would encourage and facilitate the transfer of knowledge regarding violations of arms control agreements. An efficient, confidential mode of knowledge transfer perhaps could be encouraged by rewards and penalties.

Proposal Abstract H7(A62)

1. **Arms Control Problem:**
   (a) General and complete disarmament
   (b) Regional arms control - Europe

2. **Verification Type:**
   (a) Non-physical/psychological inspection
   (b) International control organization

3. **Source:**
   Melman, Seymour, "Inspection by the People". In Preventing World War III: Some Proposals, pp. 40-51. Edited by Quincy Wright, William M. Evan and Morton Deutsch. New York: Simon and Schuster, 1962.

4. **Summary:**

Inspection by the people involves an effort to organize the population of the inspected country into a random, far-flung network of people who would report to an International Disarmament Organization (IDO) any evidence of evasion activity. Any major evasion effort would require the collaboration of thousands and the substantial backing by the surrounding population as well as an important segment of the government.

The principal legal requirement of this method is that each country require in its code of law that every citizen report to the IDO any evidence of evasion. Failure to do so would be punishable. Included in the disarmament agreement would be provisions for the right of the IDO to address itself to the population of a country including the right to minimal use of the press, radio, TV and face-to-face communication. Leaders of each country would also be required to participate in the IDO's public statements to the population.

The disarmament agreement would also include means for the population to reach the inspectorate. Test mail could be used to ensure that the postal service provided an access route. By granting diplomatic immunity to IDO personnel, any person reporting an evasion could be assured that if he wanted protection from the IDO, even to the extent of being moved abroad, he could have it. The IDO might also be connected with information centers and technical libraries to which the population would have free access. Rewards for reporting evasions and guarantees of protection would be used.

 H8(A63)

Proposal Abstract H8(A63)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   (a) Non-physical/psychological inspection
   (b) International control organization

3. **Source:**
   Bohn, L.C. "Whose Nuclear Test: Non-physical Inspection and the Nuclear Test Ban". In Weapons Management in World Politics: Proceedings of the International Arms Control Symposium, December 17-20, 1962, pp. 474-487. Edited by J.D. Singer. Ann Arbor, Michigan: 1963.

4. **Summary:**

   This proposal attempts to deal with the problem of uncovering the source of tests made illegal by a comprehensive nuclear test ban. The author notes that while seismic and radiation detection techniques can generally determine that a nuclear explosion has occurred, these systems are not always able to locate the event. A non-physical inspection approach is offered as a supplement to physical inspection.

   Five basic subsystems are suggested in this proposal:

   (1) A limited public reporting system would encourage citizens to report evidence of nuclear tests or related activities to an international control agency. Incentives, as well as guarantees of safety, would be offered to informants.

   (2) Periodic questioning of selected individuals before an international committee would be undertaken. This might be limited to perhaps 100 top officials and scientists in countries with a known or potential nuclear capability. The aim would be to discover participation in or knowledge of illegal activities connected with nuclear tests. Legitimate matters of national security would be safeguarded.

   (3) Cooperative nuclear research by scientists from around the world would encourage close personal relationships between leading nuclear scientists so that a violation of an agreement would be less likely to remain the secret of one or two. The chances of a fundamental breakthrough by only one nation would be minimized as well. Asylum could be provided for a scientist wishing to report violations.

   (4) Exchanges of scientific personnel between potential "enemy" nations would offer benefits similar to item 3 above.

   (5) If and only if it could be developed as a reliable technique, polygraph questioning of selected individuals might be used to assure the truthfulness of individuals under questioning. A limited number of people would be required to undergo such tests.

Proposal Abstract H9(A83)

1. **Arms Control Problem:**
   Chemical and biological weapons - use - "yellow rain"

2. **Verification Type:**
   Non-physical/psychological inspection

3. **Source:**
   Schiefer, H.B. "Verification of Chemical Weapon Use: Retrospect". In Compliance and Confirmation: Political and Technical Problems in the Verification of Arms Control of Chemical Weapons and Outer Space, pp. 64-66. Edited by H. von Riekhoff. Ottawa: Norman Paterson School of International Affairs, Carleton University, 1986.*

4. **Summary:**
   After briefly describing the Geneva Protocol of 1925 and the 1972 Biological Weapons Convention (see abstract M5(T72)), some of the difficulties inherent in verifying a violation of a chemical weapons agreement are discussed. Such verification can only be conducted where there is agreement on the chemicals to be banned. there must also be appropriate methods for identifying the chemical and monitoring other states' activities to make sure they are complying with the agreement. The article then reviews a case study - the reports of 'yellow rain' in Laos and Kampuchea in 1976. One specific problem is examined in this instance, the difficulty of verifying whether the incident was due to chemical warfare or whether it resulted from a toxin produced naturally in the environment. The suspected toxin in this case was a mycotoxin, which may be produced either synthetically or from certain fungi in the environment.

   A verification scheme was formulated and executed which sought to ascertain the source of these mycotoxins. This involved informal interviews with alleged victims which scrutinized the consistency of various accounts and considered alternate explanations which might be found to account for the phenomenon of 'yellow rain'. While many inconsistencies in the evidence were found, a credible skeleton of information remained. Basically, it is known that many people fled their homelands, giving accounts of mysterious yellow rains which caused sickness and death. Through the use of analogy, the author demonstrates how one might reasonably arrive at a single conclusion despite somewhat inconsistent evidence. The findings also showed that some mycotoxins might be produced in these areas, but the one suspected in this instance - trichothecene - is not found there. Finally, no other disease is known which would produce death in man, animal, and plant simultaneously, so that the possible occurrence of some natural epidemic is ruled out.

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* Proceedings of a conference held in 1983.

On the basis of these findings, it is concluded that it will be difficult to prove that an incident was not due to any natural phenomena where mycotoxins are found naturally in the environment. This is true in spite of the fact that the cause is generally known, regardless of the lack of proof. It is recommended that a more effective verification procedure be sought which is equitable, non-discriminatory, reciprocal, and preserves national sovereignty.

CHAPTER I

SHORT-RANGE SENSORS

The discussion in this chapter focusses on relatively short-range sensing devices. Because of the limited range of these devices their use usually implies some form of physical entry into the territory of the party being monitored either to install and maintain the sensor or because the technique is intended for use by personnel as part of a system of on-site inspection.

A. Inspection Equipment

Two types of close range sensors fall within the scope of this chapter. The first category includes devices and techniques which are intended to be carried or employed by on-site inspectors in the course of their duties. These might include devices like portable chemical agent alarms or Geiger counters. Portable laboratories for testing samples as well as the techniques which could be used in these laboratories can also be placed into this category.

The use of such equipment may well be described as intrusive in the sense that it could provide an opportunity for collecting military or proprietary information outside the scope of the relevant arms control agreement. Thus the agreement may well have to specify in detail the inspection equipment which can be used.

B. Automatic Sensors

The second category of short-range sensors discussed in this chapter includes devices which are implanted relatively near the object to be monitored and left unattended. These sensors would be periodically visited by inspectors to collect recorded data or monitored from a distance by the verification body via telecommunications links. An example of such devices are special seals which might be used to ensure that values, doors and other equipment in a production plant are kept closed.

So-called "black boxes" are treated here as a form of this type of sensor. The term "black box" is intentionally ill-defined, perhaps so those being monitored will not know exactly what is being recorded. It has sometimes been proposed that the country being monitored should be provided with a duplicate "black box" so that it can check that its mechanism will collect only information authorized by the arms control agreement (see for example the PNE Treaty, abstract C52(T76)).

Many sensors developed originally for use in combat situations to monitor enemy troop and vehicular movements have utility for verification of arms control agreements. They might be applied directly with little modification, as in monitoring a demilitarized zone, or they might serve as a basis for further research to design a more appropriate verification device. A number of categories of such devices are listed below in order to give a general appreciation of the state of technology in this area.

(1) Chemical sensors include a portable alarm system for detecting nerve gas agents below lethal concentrations, capable of being transported by an inspector and possibly for modification as an automatic sensing device. It might also be adapted to the detection of other chemical agents. Other chemical sensors include one for detecting chemical emanations from the human body.

(2) Acoustic sensors which detect sounds in the immediate vicinity and transmit a signal to a remote controller for evaluation.

(3) Vibration sensors which detect movements of traffic and even of personnel within a range of a few metres. These sensors can be distinguished from the seismic sensors discussed in chapter K because of their considerably shorter range of operation. Furthermore, these sensors merely trigger an alarm or another sensor (acoustic sensors for example) rather than producing data on seismic waveforms which is a function of the longer-range seismic sensors.

(4) Radio frequency detectors used to detect the presence of radio frequency emissions from equipment (e.g. from spark plugs) in the immediate vicinity.

(5) Pressure sensitive sensors which transmit a signal when touched.

(6) Magnetic sensors used for detecting metallic objects such as vehicles or rifles.

(7) Visual surveillance devices include a wide variety of photographic equipment, television, low light television and infra-red sensors.

(8) A system called RECOVER (Remote Continuous Verification) has recently been designed to verify that short-range sensors (containment and surveillance equipment including cameras) are functioning properly by transmitting information on the status of the equipment to a central monitoring authority. Originally intended to supplement the IAEA safeguards system (see, for example, abstract D45(G83)), RECOVER has also been considered for application in verification of a chemical weapons convention (see abstract I20(G85)).

Although the implantation of unattended sensing devices on the territory of a state can be done clandestinely in a state of war it must be done with the concurrence of the state being monitored when done for the purpose of monitoring an arms control agreement. The limitations of specific sensors compared with the general observational powers of a human inspector may make them more acceptable than inspection teams. Their use may also reduce the manpower costs of the verification system.

Proposal Abstract I1(A78)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Short-range sensors - seals

3. **Source:**
   Ulrich, R.R. Fiber Optic Safeguards Sealing System. Adelphi, Maryland: Harry Diamond Laboratories, 1978. NTIS AD-A052 312.

4. **Summary:**
   The report describes the progress of continuing research undertaken for the Arms Control and Disarmament Agency of the United States regarding the development of tamper-resistant/tamper-indicating seals intended for arms control applications. The system consists of fiber optic seals and ancillary equipment which assembles, photographs and identifies the seals in the field. The equipment is described, results of preliminary environmental tests are given, and detailed operating procedures are outlined.

Proposal Abstract I2(A69)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles

2. **Verification Type:**
   Short-range sensors - monitoring devices

3. **Source:**
   Persley, Merle J., James W. Kauffman, and James P. Moran. Further Investigation of Rocket Launch-Phase Inspection Techniques: Summary. Cambridge, Mass.: Block Engineering Inc., 1969. ST-132/R-36. NTIS AD 701 255.

4. **Summary:**

   The aim of the study reported here was to develop techniques for the arms control monitoring of missile and space vehicle launches. The report evaluates the results of actual trials at a missile test range of a comprehensive, mobile, passive, optical instrumentation system composed of cameras, spectrometers and ancillary equipment.

   The study concluded that remote optical sensing techniques can provide meaningful information for arms control missile inspection purposes. Missile characteristics which can be determined by such methods include: thrust, specific impulse, propellant type, construction details, launch weight and event times. Several improvements to the instrumentation are recommended for further study. Study of the capabilities of airborne and satellite-borne platforms for inspection purposes is also recommended. A separate volume of the report describes in detail the instrumentation used.

Proposal Abstract I3(A71)

1. **Arms Control Problem:**
Nuclear weapons - ballistic missiles
- anti-ballistic missile system

2. **Verification Type:**
Short-range sensors - monitoring devices

3. **Source:**
Fubini, E. "Reconnaissance and Surveillance as Essential Elements of Peace", and summary of discussion. In Impact of New Technologies on The Arms Race, pp. 152-160. Edited by B.T. Feld, et al. Cambridge, Mass.: MIT Press, 1971.

4. **Summary:**

The author contends that to verify a SALT agreement adequately, satellite reconnaissance is not sufficient. Satellites suffer from a number of weaknesses including:
(1) limitations imposed by the weather and nightfall,
(2) limitations imposed by size and cost factors, and
(3) limitations resulting from the opacity of many objects.

In order to supplement verification by satellite, the author suggests:

> The great usefulness of "transparent black boxes" which could be located anywhere in the US or Soviet territory and equipped with a sensor of some kind. The location could easily be checked, the size would be small, the sensors would limit strictly the scope of the information, with both parties fully knowledgeable of the details of the box. A typical transparent box would consist of a camera capable of taking consecutive pictures (say every 30 seconds) of a missile silo to prove that new missiles are not being substituted for old ones (p.154).

The major advantage of such a system is that it is limited as to the scope of the information it is capable of providing. In a situation of partial trust, this "limitedness" could help reduce tensions because the party being monitored knows what he is facing.

The objection that the "black box" cannot provide 100% assurance is not valid, according to Fubini. No system of verification can do this.

A number of interesting points emerged in the subsequent discussion of Fubini's presentation. It was pointed out that there had been extensive consideration given to the idea of "black boxes" during the test ban negotiations of the early sixties. The main stumbling block was the demand for absolute assurance of compliance which resulted in the small monitoring boxes growing into "unwieldy monstrosities". This unfortunate experience may have blinded governments to the possible utility of "black boxes" as a means of verification.

If the black box were recognized from the beginning to have only a limited function, then it need not grow into a monstrosity. An example of such a limited use for a black box would be the monitoring of a large, sophisticated commercial air-traffic control radar in order to guarantee that it does not have an ABM capability. The properties of limitedness and pre-determination which are built into a black box are not possible with air or satellite surveillance; and especially not with human reconnaissance.... It is true that one side could jam such a device and that no-one could prevent this, but the box could be so constructed that the other side would know that the box was being jammed (p.159).

 I4(A81)

Proposal Abstract I4(A81)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - partial test ban
   - peaceful nuclear explosions

2. **Verification Type:**
   (a) Short-range sensors - monitoring devices
   (b) On-site inspection - selective
   - sampling
   (c) Seismic sensors - intra-border stations

3. **Source:**
   Mann, Paul. "Television Proposed to Verify Treaties". Aviation Week and Space Technology 115, no. 112 (September 21, 1981): 21-22.

4. **Summary:**
Mann reports on some remarks made by Eugene Rostow, the director of the US Arms Control and Disarmament Agency. Rostow proposed the use of continuous television monitoring for on-site verification of future US-Soviet strategic weapons treaties. Ultimately, this could involve human inspectors. Rostow commented that "this fuss about on-site inspection" is "fundamentally trivial" (p.21) and pointed to two precedents involving the use of inspectors for on-site verification: the Threshold Test Ban Treaty of July 1974 (see abstract K54(T74)) and the Treaty on Peaceful Nuclear Explosions of May 1976 (see abstract C52(T76)) which have been signed but not ratified by the US Senate. The Peaceful Nuclear Explosions Treaty allows human observers to confirm the yield of an explosion under certain specified circumstances. The Treaty allows confirmation of the peaceful purposes of facilities and installations associated with a detonation project. Inspectors are also permitted to examine research and measurement data and rock core or rock fragments removed from the emplacement holes drilled for the explosive devices. A local seismic network can be installed and operated to monitor any explosion with a planned aggregate yield exceeding 500 kilotons. Photographs may be requested by observers, but the photography is to be carried out by the party conducting the explosion. These extensive verification provisions have never been utilized.

Rostow noted that verification capabilities do not permit the monitoring of weapons production facilities nor the counting of the number of warheads on a missile. Verification of theater nuclear weapons will be as difficult as verification of strategic weapons.

Proposal Abstract I5(G62)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   (a) Short-range sensors - monitoring devices
   (b) Seismic sensors - intra-border stations
   - international network
   (c) International control organization

3. **Source:**
   United Kingdom. "A document prepared by 3 United States and 3 Soviet scientists attending the Xth Conference on Science and World Affairs, Cambridge 1962". ENDC/66, 4 December 1962.

4. **Summary:**
   The six scientists suggest the use of Automatic Recording Stations which would be sealed and tamper-proof as well as self-contained. They would be installed by the host government and periodically returned to the International Control Commission for inspection, replacement and repair. A standard explosive blast would be used for calibration purposes. The number of stations would be large enough to provide a good check of the seismic data supplied by a world-wide network of seismic stations. Such an arrangement would reduce the possibility of unidentified events and increase location precision. It would also mean the Commission will need fewer on-site inspections of suspicious events.
   The Commission would be able to request immediate return of the sealed instruments. Seismic data would be collected periodically by the Commission. The stations located in the USSR could be manufactured in the US and vice-versa.

5. **Selected Comments of States:**
   In an Izvestiya article reproduced as Soviet working paper ENDC/67 (7 December 1962), several Soviet scientists support the proposal for automatic seismic stations. They suggest that servicing of the stations be carried out by periodically changing standard sets of cassettes sealed by an international authority and loaded with films and power supply units.

Proposal Abstract I5.1(A86)

1. **Arms Control Problem:**
   Nuclear weapons - cruise missiles

2. **Verification Type:**
   (a) Short-range sensors - monitoring devices
   (b) On-site inspection - selective
   (c) Remote sensors

3. **Source:**
   Lewis, Patricia. "Why Cruise Could Be Beyond Control". New Scientist (23 October 1986): 61.

4. **Summary:**

Any verification system for an agreement concerning cruise missiles would have to count the missiles and to distinguish those with conventional warheads from those with nuclear ones. This is almost impossible using remote sensors because of the missiles' small size, mobility and ease of launching. Consequently, verification will require cooperative schemes.

Any verification scheme will have to operate at the site of production and during the loading of missiles onto their launchers. Tamper-proof tags would be installed during manufacture. A detection system at the loading bay of the launch vehicle would count the missiles and distinguish between nuclear and conventional warheads. Inspectors would periodically check ships, aircraft and military installations for untagged weapons. The possibility that weapons produced at an unmonitored factory and hidden, could not be eliminated by this verification system.

Several tagging technologies are under investigation in the US including "systems based on acoustic holograms, microchip technology and special moulds that would imprint an intricate pattern on the surface of the missile".

Nuclear warheads could be monitored at the launchers' loading bays by devices to detect naturally emitted radiation from the warheads nuclear material. This method could be defeated, however, by shielding in the warhead. An alternative approach employs a beam of neutrons (for example) which passes through the warhead stimulating the emission of characteristic radiation when nuclear material is present. Any shielding would prevent the passage of the beam and would be detected.

The amount of cooperation required for this type of verification system is so extensive that it implies that trust between the parties was already so great that they could take each other at their word, making such elaborate verification redundant.

Proposal Abstract I6(G66)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable materials "cutoff"

2. **Verification Type:**
   (a) Short-range sensors - monitoring devices
   (b) On-site inspection - selective

3. **Source:**
   United States. "Working paper on an inspection method for verifying the status of shutdown plutonium production reactors". ENDC/174, 14 April 1966.
   For more detail see: "Description of a monitoring system for shutdown nuclear reactors". ENDC/176 and Corr. 1, 11 August 1966.

4. **Summary:**
   The paper describes a method of ensuring continued shutdown of plutonium producing reactors during periods between inspections. The method involves four concepts:
   (1) Use of a "target material" placed in a reactor case, which is of such a nature that it will become radioactive in the event of reactor operation;
   (2) Use of wire or tape to fix this target material in position;
   (3) The tape is of such a nature that it is unique and hence any substitution of the equipment would be detected; and
   (4) Use of an exterior seal at each end of the channel in which the target material is inserted, to assure the inspection team that the wire or tape will have remained in position between inspections.

   An international inspection team of two professional-level and two technician-level specialists can install the system without damaging the reactor, in about one week. Return inspections which would be spaced several months apart and involve checking seals and replacing tapes, would only take one or two days each.

Proposal Abstract I7(G84)

1. **Arms Control Problem:**
   Nuclear weapons - partial test ban

2. **Verification Type:**
   Short-range sensors - sampling

3. **Source:**
   United States. Department of Energy. Sandia National Laboratories. "Buoys for Collecting Radioactive Fallout". Sandia Technology 8, no. 2 (November 1984): 12-15.

4. **Summary:**

This article describes Sandia Laboratories' work on buoys designed to collect and analyse dry fallout and rainout from atmospheric nuclear explosions. Data from the buoys would be regularly transmitted over the National Oceanographic and Atmospheric Agency's satellite system to land stations. The free floating buoys would be scattered over the southern oceans to detect evidence of atmospheric blasts such as may have occurred in the South Atlantic on 22 September 1979. They would not be recovered unless particularly interesting data were recorded.

The buoys collect rainwater through a funnel and analyse it for gamma rays emitted during the decay of radioactive debris. If the analysis reveals debris from a nuclear explosion, the buoy filters the water, saves the filtrate for later laboratory examination and discharges the water. If analysis results are negative, the water is discharged without being filtered.

The article contains useful pictures and graphs.

Proposal Abstract I8(G76)

1. **Arms Control Problem:**
   Chemical weapons - destruction of facilities
   - destruction of stocks

2. **Verification Type:**
   Short-Range sensors - seals
   - monitoring devices

3. **Source:**
   United States. "The use of seals and monitoring devices in CW verification". CCD/498, 29 June 1976.

4. **Summary:**
   Seals and monitoring devices could be used to ensure that moth-balled facilities are not reopened and to assist on-site observers in monitoring destruction of stockpiles. The paper describes several devices:

   (1) Fibre optic seals:* Such seals must be inspected periodically to detect tampering. Hence depending on the frequency of inspection, a significant period of time could elapse before the tampering was detected. This problem could be overcome if the seal was monitored remotely. A device to do this is being developed. Signals from the device could be transmitted over standard telephone lines or by satellite. The seals would be quite cheap.

   (2) Cameras: These could be employed to provide continuous observation. For example, closed circuit TV could permit surveillance of areas where there is a toxic hazard. It could also enable one observer to watch several places simultaneously. Development of a tamper-resistant system has proven difficult but a prototype exists. The system could include data storage capacity for up to 90 days and a motion detector.

   Alternatively, cameras could be set to run only when triggered by unauthorized activity. A compact tamper-resistant camera package has been developed which includes a motion detector trigger. The camera could also be programmed to take pictures at fixed or random intervals. This package can run unattended for 3 months.

   (3) Tamper indicating containers: Such devices would be especially useful in protecting flow-meters. Any penetration of the device leaves indications which are impossible to repair. Fibre optic seals would be used to fasten any openings in the container.

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* See also CCD/332, abstract I16(G71).

 I9(G79)

Proposal Abstract I9(G79)

1. **Arms Control Problem:**
   Chemical weapons - destruction of stocks
   - production
   - use

2. **Verification Type:**
   Short-range sensors - sampling
   - monitoring devices

3. **Source:**
   Finland. "Working paper on definitions of chemical warfare agents and on technical possibilities for verification and control of chemical weapons with particular regard to a Finnish project on creation on a national basis of a chemical weapons control capacity for possible future international use". CCD/381, 27 July 1972.
   See also: - "Working document: Chemical identification of chemical weapons agents - Finnish project". CD/14, 25 April 1979.
   - CD/PV.31, 26 April 1979.
   - CD/PV.117, 14 March 1981.
   - J.K. Miettinen, "A Neutral View on Chemical Warfare and Arms Control", In Chemical Weapons and Arms Control. Views of Europe, pp. 32-41, (Rome, 1983); see abstract C114(A83).

4. **Summary:**

According to Finland in CCD/381, economic records monitoring alone is insufficient to monitor a CW ban. There is a need for additional, generally acceptable, international verification mechanisms. National systems could provide a basis for such an eventual international mechanism.

In CD/14 Finland outlines its research project, which began in 1972, on the verification role of instrumental analysis of CWs. The goal of the project is to create a national CW verification capacity which could be put to international use. Specifically, it is an attempt to develop analytical methods for the detection, in samples, of agents to be prohibited. Organophosphorous agents are focussed upon since they are considered the most potent CWs.

The techniques developed could be useful in three different activities: verification of destruction of stocks, verification of non-production, and verification of alleged use of CWs. The techniques could be of service regardless of the modalities of verification agreed upon. They would be useful for national verification or any combination of national inspection and international elements. They could be useful in connection with an

investigation ordered by the Security Council. They could also meet some of the concerns expressed by developing countries about difficulties in carrying out verification using their national means alone.

Finland has presented several working papers since 1972 describing progress and results of the project. These include:

- CCD/412, 14 August 1973,
- CCD/432, 16 July 1974,
- CCD/453, 4 July 1975,
- CCD/501, 2 July 1976,
- CCD/577, 22 July 1978, and
- CD/164, 19 March 1981

In addition, Finland has prepared a series of "Blue Books" which contain the results of the project. The "Blue Book" series consists of the following titles which are introduced as working papers and have been distributed to the members of the Conference on Disarmament:

- "Chemical and instrumental verification of organophosphorous agents" (Helsinki: 1977) - see CCD/554, 19 August 1977;
- "Identification of potential organophosphorous warfare agents: an approach for the standardization of techniques and reference data" (Helsinki: 1979) - see CD/39, 16 July 1979;
- "Identification of degradation products of potential organophosphorous warfare agents" (Helsinki: 1980) - see CD/103, 24 June 1980;
- "Trace analysis of chemical warfare agents: an approach to the environmental monitoring of nerve agents" (Helsinki: 1981) - see CD/196, 16 July 1981;
- "Systematic identification of chemical warfare agents: identification of non-phosphorus warfare agents" (Helsinki: 1982) - see CD/229, 29 July 1982;
- "Systematic identification of chemical warfare agents: identification of precursors of warfare agents, degradation products of non-phosphorus agents and some potential agents" (Helsinki: 1983) - see CD/392, 13 July 1983;
- "Technical evaluation of selected scientific methods for the verification of chemical disarmament" (Helsinki: 1984) - see CD/505, 13 June 1984; and
- "Air monitoring as a means for verification of chemical disarmament; C.2 development and evaluation of basic techniques, part I" (Helsinki: 1985) - see CD/614, 12 July 1985.
- "Air monitoring as a means for verification of chemical disarmament; C.3 field tests, part II "(Helsinki: 1986) - see CD/719, 25 July 1986.

Future "Blue Books" will cover the following topics:

(1) automatic "black box" monitoring of agent destruction facilities (incinerators);
(2) the operation of transportable and mobile laboratories; and
(3) immunological analytical methods applied to warfare agent monitoring.

Proposal Abstract I10(G82)

1. **Arms Control Problem:**
Chemical weapons - destruction of stocks

2. **Verification Type:**
(a) Short-range sensors - monitoring devices - RECOVER
- sampling
(b) On-site inspection - selective

3. **Source:**
Sweden. "Working paper on monitoring destruction of stockpiles of chemical weapons and chemical warfare agents". CD/325, 6 September 1982.
See also: - Indonesia and Netherlands. "Letter dated 31 March 1982 from the heads of the delegations of Indonesia and the Netherlands transmitting a document entitled 'Indonesia and the Netherlands - working document - destruction of about 45 tons of mustard agent at Batujajar, West-Java, Indonesia'", CD/270, 31 March 1982.

4. **Summary:**
This technical paper focuses on verifying the destruction of two types of chemical weapons agents, nerve gas and mustard gas. The methods employed to destroy these agents could be used to explore possible verification procedures for a chemical weapons convention. The model for the destruction of nerve gas is the method used by a United States Army facility in Utah. The chemical agents are burned in a furnace and verification is accomplished by monitoring pipelines which lead from the storage tanks to the reaction vessels. Random samples for checking the type of agent by gas chromatography can be taken by an automated process. A verification authority would however, have to inspect the installation and the function of facilities as well as periodically and randomly check the performance of the destruction process in order to ensure effective verification.

The model for the destruction of mustard gas is based on the method outlined by Indonesia and the Netherlands in CD/270, 31 March 1982. The method was used to destroy about 45 tons of Mustard Agent at Batujajar, West-Java, Indonesia in 1979. On-site inspection to verify the incineration of the mustard gas in a furnace would provide reliable, cheap verification. Remote monitoring of the type used to verify nerve gas destruction would also be possible, but would be very expensive to set up. The advantage of a smaller facility like that used in Indonesia, even though it can handle only small quantities of chemical agent, is that it can be built at the site of the stockpile and removed after destruction is completed.

The Swedish paper also comments on the utility of the Remote Continual Verification System (RECOVER) developed by the IAEA for monitoring an agreement to destroy CWs. RECOVER demonstrates that verification information can be transmitted over long distances but since the need for on-site inspection differs for different processes, the cost/benefits of the transmission system may be affected.

Among the paper's conclusions are:

(1) On-site inspection is necessary at least during construction of a destruction facility;

(2) Occasional on-site inspections would be necessary during the destruction period; and

(3) Destruction at small, simple facilities may have to be followed continually by on-site inspection.

Proposal Abstract I11(G83)

1. **Arms Control Problem:**
Chemical weapons - destruction of stocks

2. **Verification Type:**
(a) Short-range sensors - sampling
(b) On-site inspection - general

3. **Source:**
United States of America. "Illustrative on-site inspection procedures for verification of chemical weapons stockpile destruction". CD/387, 6 July 1983.
See also: - Sweden. "Working paper on monitoring destruction of stockpiles of chemical weapons and chemical warfare agents". CD/325, 6 September 1982, (see abstract I10(G82)).
- Sweden. "Verification of the destruction of stockpiles of chemical weapons". CD/425, 18 January 1984 (See abstract I13(G84)).
- United States. CD/PV.236, 23 August 1983.

4. **Summary:**
This technical paper outlines the practical aspects of the United States' approach to verification of destruction of chemical weapons stockpiles. In CD/PV.236, the United States explains that the paper is designed to meet Soviet concerns about the intrusiveness of on-site inspection of stockpile destruction. The United States recognizes the importance of cooperation between national and international personnel. The United States also expresses its willingness to restrict verification to the actual destruction step and to use data generated during routine facility operations for verification purposes.

The paper outlines possible verification measures for an operational destruction facility in the United States: the Chemical Agent Munitions Disposal System (CAMDS) at Tooele Army Depot, Utah. The CAMDS facility is an industrial-size prototype used for the destruction of chemical weapons and storage vessels containing mustard agent or nerve agents GB or VX. The prototype is being used to develop a technical data package for use in designing and building the first full scale United States disposal facility on Johnston Atoll in the Pacific Ocean.

The paper discusses general principles of verification applicable to any process for chemical agent destruction and specific procedures which could be used at CAMDS. Incineration is the preferred method of destruction for chemical agents at the CAMDS facility. The two types of incineration processes used there impose different requirements on the verification procedures so they are discussed separately in the paper. In situ incineration involves incinerating the chemical agent without first draining it from a munition or bulk container. The identity and purity of agents could be verified by sampling them immediately before incineration and analysing the sample automatically with an on-line dual column gas chromatograph. Procedures will differ depending on the nature of the agent. The quantity of agent destroyed could be gauged by weighing containers immediately before and after passage through the metal parts furnace.

Confirmation of destruction could be achieved by monitoring the temperature of the furnace and the time taken for incineration. The absence of diversion pathways could be verified by engineering inspection of the facility before destruction commences and by direct surveillance of key process areas. Data from sensors would be transmitted to a central monitoring station and recorded.

Injection-method incineration, in contrast, involves draining the chemical agent from the munition or container and then injecting it into an incinerator. Metal components are incinerated separately from the chemical agent. In this type of incineration, the identity and purity of the agent could be verified by sampling close to the inlet of the liquid incinerator and analysing this sample. The quantity of agent destroyed could be verified with a flow-meter near the inlet of the liquid incinerator. Actual destruction could be verified through procedures similar to those used in verification of in situ incineration.

The continuous presence of trained inspectors during destruction would be necessary to ensure the efficient functioning of automatic sampling and analysis equipment and to provide visual surveillance.

Validity of data could be ensured by having the inspectors examine the facility before destruction and by their participation in the calibration of sensors. Tamper-detecting designs for sensors would provide a secure data collection system. Data would be converted from analogue to digital form when necessary and an "authentication" scheme would be adopted. The data authentication system can be used with little increased cost because of the availability of low cost microprocessors. The cost of authenticating television images, however, would be substantial. A tamper-detecting box and cable shielding could ensure the integrity of television images.

The paper also discusses an elaborate security system to prevent deception of a single sensor at a given time. This involves item counters triggering television surveillance and alerts if sensors do not record the appropriate information within the normal time period.

The paper includes schematic diagrams showing the incineration methods and verification procedures.

Proposal Abstract I12(G84)

1. **Arms Control Problem:**
Chemical weapons - destruction of stocks

2. **Verification Type:**
(a) Short-range sensors - monitoring devices
(b) On-site inspection - general

3. **Source:**
Federal Republic of Germany. "Verification of the destruction of chemical weapons". CD/518, 17 July 1984.

4. **Summary:** *

This paper is a report on a workshop conducted by the government of the FRG on the verification of the destruction of chemical weapons (12-14 June 1984). The government concluded that effective verification can be obtained only with a continuous monitoring system involving checks by inspectors and monitoring by tamper-proof measuring devices. However, attempts should be made to integrate technical monitoring devices with inspections so that the intrusiveness of on-site inspection can be reduced.

The paper also provides summaries of three lectures given during the workshop:

(1) "Verification of the destruction of chemical weapons under a chemical weapons convention" by Professor Dr. Johannes Pfirschke, Federal Ministry of Defence,

(2) "The use of optoelectronic sensors to support verification by international inspectors" by Dr. H. Bueker, Nuclear Research Center, Juelich, and

(3) "Application of mass spectometry to qualitative analysis of chemical warfare agents in demilitarisation of CW agent supplies" by Dr. B. Odernheimer, Federal Armed Forces Defence Science Agency for NBC Protection (WWDBw ABC-Schutz).

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* The following abstract is based on the conclusions drawn by the FRG in the introduction to the paper.

Proposal Abstract I13(G84)

1. **Arms Control Problem:**
   Chemical weapons - destruction of stocks

2. **Verification Type:**
   (a) Short-range sensors - sampling
   (b) On-site inspection - general

3. **Source:**
   Sweden. "Verification of the destruction of stockpiles of chemical weapons". CD/425, 18 January 1984.
   See also: - United States of America. "Illustrative on-site inspection procedures for verification of chemical weapons stockpile destruction". CD/387, 6 July 1983 (see abstract I11(G83)).
   - Sweden. "Working paper on monitoring destruction of stockpiles of chemical weapons and chemical warfare agents". CD/325, 6 September 1982 (see abstract I10(G82)).

4. **Summary:**

This working paper is a response to American working paper CD/387 and a visit to the Chemical Agents Munitions Disposal System (CAMDS) site at Tooele Army Depot, Utah (15 and 16 November 1983) by representatives of delegations to the Committee on Disarmament. The working paper analyses the need for continuous on-site inspection of the destruction of chemical weapons and recommends possible improvements of the CAMDS facility to satisfy verification needs. The paper proposes consideration of a combination of continuous on-site inspection and short-range sensing. It evaluates whether the combination would incur lower costs than the sum of the costs for the two methods separately.

The paper outlines an international verification regime with the following elements:

(1) International on-site inspection of the destruction facility prior to operation, at the beginning of the destruction process and during repairs or maintenance;
(2) Random international on-site inspections (with an agreed number of such inspections);
(3) Tamper-proof communication networks for transmission of data; and
(4) International on-site inspection to observe destruction of the facility or its conversion for other destruction purposes.

The paper proposes improvements for the CAMDS facility and concludes that it is impossible to design a completely reliable system which does not require any inspectors, but the proposed modifications and reliable data transfer would reduce the need for continuous on-site inspection.

Proposal Abstract I14(G71)

1. **Arms Control Problem:**
   Chemical weapons - production
   - research and development
   - stockpiling

2. **Verification Type:**
   (a) Short-range sensors - sampling
   (b) International exchange of information
   (c) National self-supervision

3. **Source:**
   Canada. "Working paper on atmospheric sensing and verification of a ban on development, production and stockpiling of chemical weapons". CCD/334, 8 July 1971.

4. **Summary:**

Because of technical and physical limitations, remote air sampling is not feasible as a verification method save perhaps in the case of monitoring small countries and even then only for certain agents.

It might, however, be possible to create a national network of monitoring stations which would gather data on the presence of organophosphorous compounds in the atmosphere of a state. Such stations would be analogous to existing North American stations which measure the concentration of air pollutants over cities. The nerve agents have their own distinct chemical signatures not easily confused with common industrial pollutants.

The national network of stations would collect the raw data on concentrations of the agents in the atmosphere, while transmission and summary analysis of the data could be done within the framework of international exchanges such as now exist through the World Meteorological Organization.

Proposal I15(G71)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   (a) Short-range sensors - sampling
   (b) On-site inspection - selective

3. **Source:**
   Japan. "Working paper on a biological approach to the question of verification of the prohibition to chemical weapons - organophosphorous chemical agents". CCD/343, 24 August 1971.

4. **Summary:**

Japanese governmental guidelines for health safety of personnel in plants producing or using organophosphorous compounds have established four criteria for periodical medical examinations:

(1) decline in level of cholinesterase in the blood;
(2) excessive perspiration;
(3) contraction of pupil; and
(4) muscular fibrillation of the eyelids and face.

Of these, the first is the most sensitive and is suggested as a possible verification method. Measurement of the activity of cholinesterase in the blood involves relatively simple techniques. The method requires that each worker's blood be tested three or four times prior to commencement of work so that a mean value for normal cholinesterase levels can be established. Thereafter tests every two weeks to two months are conducted depending on the toxity of the pesticide being produced in the plant.

Detection of a significant change in cholinesterase activity would not itself be sufficient to indicate the nature of the chemical compound being produced. Nevertheless, a means of verification such as this one, which covers a wide range of organophosphorous compounds, might be useful.

It might be possible to circumvent detection by this technique by building a plant using optimum safety equipment so that the possibility of employee exposure to the chemicals being produced would be totally eliminated. However, while this might reduce the effectiveness of the biological means of verification, the presence of elaborate safety equipment could itself provide useful verification data.

Proposal Abstract I16(G71)

1. **Arms Control Problem:**
   Chemical weapons - production
   - destruction of facilities

2. **Verification Type:**
   (a) Short-range sensors - seals
   - monitoring devices
   - sampling

   (b) On-site inspection - selective

3. **Source:**
   United States. "Working paper on chemical warfare verification". CCD/332, 5 July 1971.

4. **Summary:**

The paper, inter alia, describes certain safety features of a plant producing nerve gases which would be necessary to protect operating personnel. While the presence of these safety features would not constitute certain proof of nerve gas production, nevertheless, their presence would merit fuller investigation to verify that no nerve gases were being produced. These special safety features include the following:

(1) unique design of the plant,
(2) airtight walls and roof,
(3) maintenance of a continuous air pressure differential to prevent leakage,
(4) comprehensive vent controls or a single central vent,
(5) special pumps,
(6) personnel areas that are separated from process areas by airtight barriers,
(7) controls that are located exclusively in personnel areas,
(8) airtight seals, windows, airlocks,
(9) closed circuit TV,
(10) doors without handles on one side,
(11) special spray systems,
(12) special sample chambers,
(13) protective masks and clothing,
(14) emergency facilities,
(15) automatic gas alarms, and
(16) test animals.

The paper continues by listing three ways to dispose of a former nerve gas factory. These are:

(1) conversion to peaceful production activities,
(2) dismantling, or
(3) shutting down pending a decision on final disposition.

The paper proceeds to elaborate on ways of monitoring a shut down facility. Possible monitoring sensors include:

(1) Specially sealed containers could be placed a around crucial values and other equipment. While it would be impossible to ensure that unattended seals were totally inviolable, it is possible to make them highly tamper-resistant. Work in this regard has been done in connection with safe-guarding reactors and other nuclear facilities. One method is to seal equipment with fibre optic cables. Such cables have their own unique light "fingerprint" which can be recorded by photographing the polished fibre ends. Any attempt to cut this cable would destroy its "fingerprint". Other methods of indicating tampering are also possible.
(2) Seismic sensors could be used to detect the presence of vibration accompanying production activity.
(3) Closed circuit TV.
(4) Heat detectors.
(5) Automatic sampling techniques could be used in conjunction with alarm systems.

A number of analytical techniques, at various stages of development might be applicable for on-site sampling or in connection to an automatic alarm system. Before using these techniques it would probably be necessary to obtain concentrated samples from air, water or soil near the facility. High levels of purification may also be required. The following techniques are of interest:

(1) gas chromatography*
(2) infra-red spectrophotography,
(3) thin layer chromatography,
(4) nuclear magnetic resonance,
(5) emission spectrography,
(6) electron paramagnetic resonance,
(7) colourimetry*
(8) enzymatic analysis, and
(9) mass spectrometry.

The applicability of many of these techniques for on-site inspection remains to be determined. Factors to be considered include sensitivity, expense, portability, speed and simplicity of operation.

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* See also Japan, CCD/301, abstract C83(G70).

Proposal Abstract I17(G77)

1. **Arms Control Problem:**
   Chemical weapons - production
   - binary agents

2. **Verification Type:**
   (a) Short-range sensors - sampling
   (b) On-site inspection - selective

3. **Source:**
   Netherlands. "Working paper concerning the verification of the presence of nerve agents, their decomposition products or starting materials downstream of chemical production plants". CCD/533, 22 April 1977.
   See also: - CCD/PV.748, 28 April 1977.
   - CD/307, 10 August 1982 (abstract C96(G82)).

4. **Summary:**

The paper is concerned with verifying the non-production of nerve gases. The method suggested is one of comparing samples of water from upstream and from downstream of a chemical plant. By using gas chromatography, it would be possible to detect the presence of the agents themselves, their waste products or precursors even after extensive water purification. It may also be possible using this method to detect precursors of binary agents. Once a prohibited substance had been detected, an on-site inspection of the plant would be necessary. One advantage claimed for the method is its non-intrusiveness.

The paper presents a technical discussion of the method using data derived from experiments conducted on the Rhine River. A bibliography is also included.

Proposal Abstract I18(G82)

1. **Arms Control Problem:**
   (a) Chemical weapons - production
   - stockpiling

   (b) Nuclear weapons - proliferation

2. **Verification Type:**
   Short-range sensors - monitoring devices - RECOVER

3. **Source:**
   United States of America, United Kingdom and Australia. "Technical Evaluation of "RECOVER" Techniques for CW Verification". CD/271, 1 April 1982.
   See also: - Sweden, "Working paper on monitoring destruction of stockpiles of chemical weapons and chemical warfare agents". CD/325, 6 September 1982 (see abstract I10(G82)).
   - Japan, CD/PV.307, 11 April 1985.

4. **Summary:**

The paper proposes the establishment of a technical panel open to all interested states to evaluate the feasibility of using 'RECOVER' to verify the non-production of chemical weapons. 'RECOVER' (Remote Continual Verification) is a data collection network developed in the United States for use mainly in nuclear safeguards. The system is designed to transmit digital data from sensors installed at a facility anywhere in the world to a central facility. The data is transmitted securely because the system is tamper-resistant and the data is encrypted during transmission.

The technical panel could perform the following functions:

(1) Consider possible specific applications for RECOVER (for example, for monitoring discontinued chemical weapons production facilities),
(2) Identify suitable sensors and help develop new sensors compatible with the RECOVER system, and
(3) Sponsor an international demonstration project to test the monitoring system. The paper estimates that it would take two years to accomplish these tasks.

The Swedish working paper includes a review of a draft report assessment of RECOVER (see E.V. Weinstock and Jonathan B. Sanborn, <u>An Evaluation of a Remote Continual Verification System, RECOVER, For International Safeguards</u>, December 1982). The paper reports that the system could be useful and cost-effective in the safeguarding of pressurized heavy water nuclear power reactors, fast critical facilities and inactive stores of plutonium or highly enriched

uranium. RECOVER did not prove to be cost effective in monitoring other types of nuclear facilities. While it was demonstrated that information for verification could be transmitted over unlimited distances, the necessity of having on-site inspection for different processes reduced the cost-effectiveness of the system. Verification of the destruction of stockpiles of chemical weapons would probably require on-site inspection and this would reduce the cost-effectiveness and usefulness of the RECOVER technique.

5. **Selected Comments of States:**

Japan (CD/PV.307, 11 April 1985) supports the use of remote sensor technology as proposed in the RECOVER system to verify a chemical weapons convention.

Proposal Abstract I19(G83)

1. **Arms Control Problem:**
   Chemical weapons - production

2. **Verification Type:**
   Short-range sensors - monitoring devices

3. **Source:**
   Spain. "Working paper: technical aspects of a convention on chemical weapons". CD/350, 28 February 1983.

4. **Summary:**
   This technical working paper lists materials for agents considered to be "important precursors" and elaborates on recommendations for methods of aerosol inhalation toxicity determination. The paper discusses methods for the protection and monitoring of the environment during the destruction of chemical weapons. The paper also calls for research to develop suitable sensors for chemical verification (so called "black boxes") so that technical limitations can be overcome and so that the sensors can, in very specialized cases, replace on-site inspections.

Proposal Abstract I20(G85)

1. **Arms Control Problem:**
Chemical weapons - production
- stockpiling
- destruction of facilities
- destruction of stocks

2. **Verification Type:**
Short-range sensors - monitoring devices
- seals

3. **Source:**
Japan. "Application of (nuclear) safeguards remote verification technology to verification of a chemical weapons convention". CD/619, 23 July 1985.
See also: - Australia, United Kingdom, United States. "Technical evaluation of "RECOVER" techniques for chemical weapons verification". CD/271, 1 April 1982 (see abstract I18(G82))

4. **Summary:**
This working paper describes work in Japan on a "second generation" system of remote verification technology for the "safe, economic, and reliable transmittal of digital data to a central monitoring organization" (p. 1) from sensors at chemical weapons facilities. This technology would be used to verify the inactive status of chemical weapons facilities and the situation of chemical weapons stockpiles. RECOVER (Remote Continual Verification) technology was originally developed for the United States Arms Control and Disarmament Agency as a data collection system for nuclear safeguards. The first generation system used the telephone network and suffered from low reliability of hardware and a limited ability to transmit only "on-off" data from sensors. The new system adds the use of satellite telecommunications to the telephone system and will utilize hardware with greater reliability so that it will be maintenance free for about a year. The system will be capable of transmitting still images and alpha-numerical data and will be able to respond to remote commands from a monitoring centre to play back information recorded by closed-circuit television cameras at facilities. Japan states that "the technology has thus become more practical as a verification system" (p.1).
Specific verification functions which the system would be required to perform include:
(1) verification of the inactive status of chemical weapon stockpile facilities and former production facilities to be destroyed in the future;

(2) monitoring the activities of elimination facilities and permitted production facilities; and
(3) monitoring possible container abnormalities before and after trans-shipment of chemical weapons.

The working paper provides estimated costs for a verification system on a scale similar to that of the facilities discussed at a chemical weapons workshop at the Tooele Army Depot in November 1983 (see CD/424, 20 January 1984 and CD/425 abstract I11(G83)). Estimates for verification hardware for various facilities are as follows:
(1) stockpile facilities: approximately $152,000 (US);
(2) permitted production facilities: $300,000;
(3) former production facilities: $184,000; and
(4) elimination facilities: $300,000.

The paper provides figures which illustrate a conceptual design of the safeguards remote verification system (figure 1, p. 4) and a remote monitoring system of nuclear material under transportation (figure 2, p.5). Table 1 displays examples of hardware being developed in Japan as safeguards remote verification technology (p.6) and table 2 illustrates application of safeguards remote verification technology to various chemical weapons facilities (p.7).

CHAPTER J

REMOTE SENSORS

The use of long-range sensors to monitor activities within a state from outside its borders has been a revolutionary development in the field of verifying arms control agreements. The advent of this technology has greatly reduced the importance of problems arising from the intrusiveness* of many verification activities. Long-range sensors are also extensively used for intelligence gathering purposes, outside the scope of arms control agreements. Their use in this role has, to a large extent, become internationally acceptable, though counteraction to prevent unauthorized observation is presumably equally acceptable. An arms control agreement which relies on remote sensors for verification should therefore include a clause prohibiting a country from interfering with the sensors monitoring the agreement.

Verification of an arms control agreement by use of the remote sensors normally employed for intelligence gathering is often referred to as verification by "national technical means". Since virtually all remote sensors are deployed by the superpowers there could be some difficulty in relying on them to monitor a multilateral agreement unless the agreement includes some arrangement for making the information collected by the superpower available to other signatories, for example through an international agency. Because of some reluctance to divulge what is often considered intelligence information, there is a tendency for the superpowers to favour bilateral arrangements rather than multilateral ones.

Sensing devices can be termed "remote" in three senses. First, the sensor may be distant from the object it is intended to monitor, while being proximate to the personnel operating it. Shipboard or fixed site radars are an example of such a system. A second situation involves a sensor which is distant from both the object to be monitored and from the personnel controlling the sensor. An observation satellite is an example of this. Finally, a third type of sensor is one which operates in close proximity to the object to be observed while being distant from its controllers. Some of the devices used by the US Sinai Support Mission are examples of this.** For the purposes of this study, the term "remote sensor" will be used to refer to situations where the sensing device and the object to be monitored are distant from each other. Thus, the first two types of sensors described above will come within the scope of this definition. The third type is dealt with in Chapter I.

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* In this case the term "intrusiveness" refers to the physical presence of a monitoring team on the territory of the country being monitored.

** See abstract B13(T75).

The principal agent for remote sensing is the surveillance satellite. There are situations where remote sensors installed in aircraft, ships, or even on land can participate in monitoring an agreement, but this is frequently in a secondary capacity to supplement or enlarge on the satellite observations. In some circumstances, however, aircraft and other remote sensors platforms may constitute a principal element in the verification system. This may be true for regional arms control situations especially for agreements between countries which do not have access to satellites.

With regard to satellites, there are four kinds of missions that have direct relevance to arms control verification:

(1) The photographic reconnaissance mission. There are two main types, the "area surveillance" and the "close look" mission. The former involves the use of a wide angle, relatively low resolution camera which is employed to cover large areas and note discrepancies which may need further examination before they can be identified. "Close-look" satellites are directed to the identified areas of interest in order to collect more detailed information. They usually orbit at lower heights than area surveillance satellites in order to obtain more detail, and are consequently relatively short lived. They may also have specialized sensors for different purposes, for example for maritime observation. Multispectral scanners are sensors which are sensitive to multiple regions of the electromagnetic spectrum including the infra-red region. They are useful for detecting camouflage which emits a different light signature than natural vegetation. Synthetic aperture radars are powerful satellite sensors which can produce images similar to photographic cameras but have the advantage of being able to function in darkness and all weather conditions, a capability lacking in photographic reconnaissance equipment.

(2) Electronic reconnaisance. Electronic sensors gather signals intelligence (SIGINT) which includes electronic intelligence (ELINT) and communications intelligence (COMINT). They monitor electronic radiation including radar signals and radio communication.

(3) The early-warning spacecraft. The primary mission of these satellites is to detect the launching of ballistic missiles. To do this they employ infra-red sensors and TV cameras and are usually placed in geo-stationary orbits. Newer versions of these satellites also incorporate nuclear radiation sensors thus taking over, in part, the function of the fourth type of satellite considered here which is now obsolescent.

(4) Nuclear radiation detection satellites. The function of this series of satellites (the American "Vela" satellites) was to monitor compliance with the Limited Test Ban Treaty by detecting radiation emitted by nuclear explosions in the atmosphere or in outer space. Newer nuclear explosion monitoring instruments are being developed for the American Global Position System satellites, which are satellites used to aid navigation (see abstract J121(G84) and J122(A85)).

In addition to the above there are a number of non-military satellites with observational capabilities which might incidentally provide information of value for arms control verification. For example, it was recently reported that Japan is using commercially available Landsat data to monitor Soviet air bases near the Siberian coast.* There are also other developments, notably the "Space Shuttle", which by reducing the costs of launch may ultimately provide the means for orbiting larger satellites with more powerful and reliable sensors.

Because of their crucial military importance the precise capabilities and limitations of surveillance satellites remain a closely guarded secret. However there is some indication that the ground resolution of "close-look" photographic satellites is of the order of 15 cm, which is good enough to permit the identification of a wide variety of military targets unless they are camouflaged. Photographic surveillance may be limited by darkness and cloud as well as camouflage. This limitation does not necessarily apply to other sensors, though their resolution may be less than that of photographic devices.

One of the major problems with satellite surveillance is the sheer volume of data involved and the consequent length of time for processing. This could be further increased by the sometimes lengthy interval between two successive looks at the same area necessitated by the orbital characteristics of satellites, visual limitations, and the possibility of interference by the country being observed. This delay may not be important in the case of a long term arms control agreement, but could seriously affect confidence in verification in a situation of near hostilities. Newer satellites have the ability to transmit pictures in real time which may enhance verification capabilities and permit a rapid response to events. In situations where opposing forces are deployed it is frequently desirable to supplement satellite surveillance with long-range surveillance from aircraft, ship, or land bases, since such observation can be carried out at the time required, and owing to the presence of human observers, can perhaps better circumvent interference with the observation mission.

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* Defence Electronics (January 1986): p.18. See also John A. Adam, "Counting the Weapons", IEEE Spectrum (July 1986): p. 50.

Proposal Abstract J1(A61)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - aerial

3. **Source:**
   Katz, Amrom H. "Hiders and Finders". Bulletin of the Atomic Scientists 17, no. 10 (December 1961): 423-424.

4. **Summary:**

Katz proposes a military exercise to allow the United States to learn more about the mechanics of concealment and detection with regard to verification of arms control agreements. A large-scale inspection manoeuvre would deploy two teams within a quarter million square mile region of the US. One team, the hiders, would attempt to build a missile site secretly over a specified time period. The other team, the finders, would use aerial reconnaissance in attempting to monitor the activities of the other team. The hiders could be drawn from a US Army group including Army engineers. A reconnaissance wing of the Tactical Air Command could provide the finders. Mobile missile systems could be used in the exercise to improve knowledge about detection of such weapons. The use of camouflage could also be studied carefully.

The experiment would yield a lot of information about concealment as well as detection, both of which are important when dealing with a smart, imaginative opponent. The test would yield information about checking given data, monitoring, reporting, discovering evasion and establishing good communications networks. The US would also better understand its own verification capabilities and be able to evaluate proposals offered by other countries. An exercise of this type could be expanded to include NATO allies or even joint NATO-Warsaw Pact activities, but the test should probably first be conducted as an internal American exercise.

Proposal Abstract J2(G76)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) International exchange of information
   (d) International control organization
   (e) Verification, general

3. **Source:**
   United States. Arms Control and Disarmament Agency. Verification: The Critical Element. Washington, D.C.: March 1976, Publication 85.

4. **Summary:**

Verification according to this publication is the process of assessing compliance with the provisions contained in arms control agreements. its purposes are to detect violations giving timely warning to innocent parties, to deter violations and to build domestic and international confidence in the viability of arms control. Among the aspects of the verification issue discussed in this paper are the relationship of verification to intelligence gathering, factors in assessing the adequacy of a verification system and past verification proposals.

The methods of verification used depend on the character of the restrictions to be monitored, the security importance of possible violations and judgements of political benefits. National technical means which remain outside the territory of the party being monitored have several advantages. In addition to flexibility these include avoiding the need for foreign inspectors on one's territory and the need for ensuring the independence and effectiveness of inspectors. But NTMs also have their limits.

On-site inspection and monitoring can take a variety of forms including mobile teams, fixed posts, and tamper-resistant unmanned monitoring instruments. It is important to distinguish the symbolic or political value of inspection from its actual verification value. Inspections can be frustrated: one of the goals of inspection is to give evidence of such obstruction.

Exchanges of information can provide useful data to check that obtained from other sources. In addition, it involves cooperation which can serve as a precedent. But it cannot be relied on alone.

For multilateral agreements international organizations can play a verification role. But "while it is true that charges of violations by an international body are likely to carry greater weight in the world community than allegations made by adversaries, it is also true that an international body may encounter internal politically motivated opposition to seeking out evidence of violations or to

reaching a formal verdict concerning evidence that may actually be discovered" (p. 20). It is also probable that such bodies will have limited staffs and funds as well as antiquated verification technology.

The ACDA paper acknowledges that few arms control agreements are verifiable with total certainty. "Given the determination to violate an agreement and to brave the consequences of possible detection and given sufficient expenditure of resources and time and sufficient ingenuity, the most determined verification effort could probably be frustrated and evaded to some extent" (p. 21). Both the technical capabilities of monitoring methods and military and political judgements affect assessment of the verifiability of an agreement.

Three types of violations are mentioned in the paper:

(1) Local. These occur without the support of the central government.

(2) Deliberate but limited. These arise from misunderstanding or deliberate attempts to stretch an agreement.

(3) Deliberate and massive. These are attempts to achieve military or political advantage.

The third type could be mistaken for one of the less serious forms. The first two types may be less serious but should not be ignored since they could evolve into the third form.

Once a violation is detected it is necessary to respond. Factors affecting response include the quality of the evidence, the source of the evidence, the facts of the case and the objectives of national policy. Modes of response can range through requests for clarification, diplomatic protests, public requests for the activities to cease, notification that compensatory action will be taken, and denunciation and withdrawal from the agreement.

Proposal Abstract J3(A77)

1. **Arms Control Problem:**
   Any arms control problem

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International exchange of information

3. **Source:**
   Chayes, A., W. Epstein, and R.B. Taylor. "A Surveillance Satellite for All". Bulletin of the Atomic Scientists 33, no. 1 (January 1977): 7.

4. **Summary:**

The authors believe that openness of information about military activities is the key to successful arms control. It is knowledge which creates confidence. Recent progress in arms control between the superpowers only began when they acquired the capability to observe each other through satellites. The problem with this system is that the information acquired is only available to the state which launched the satellite. Furthermore, the superpowers acquire information on other countries without reciprocity. The authors continue:

> We think it would create a climate of confidence that would contribute to international peace and security if the information from satellite surveillance of military activities was publicly and universally available to all countries.... We therefore propose that a consortium of about a dozen non-nuclear weapon states, with representation from all geographical areas and social systems, should establish a satellite system for the surveillance of the military activities of all countries. The information acquired would be transmitted regularly to the United Nations and would be made available to all on an unrestricted basis in a usable form. The consortium might include such countries as Canada, Federal Republic of Germany, Japan, Sweden, Yugoslavia, Poland, Mexico, Venezuela, Nigeria, Tanzania, India, Singapore, etc.... Until an independent launch capability is available the United States and/or the Soviet Union should provide launch services.

 J4(A77)

Proposal Abstract J4(A77)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Verification, general

3. **Source:**
   Rathjens, George W. "The Verification of Arms Control Agreements". Arms Control Today 7, no. 7/8 (July/August 1977): 1-4.
   See also: - "The Verification of Arms Control Agreements". In Negotiating Security: An Arms Control Reader, pp. 41-47. Edited by William H. Kincade and Jeffrey D. Porro. Washington, D.C.: Carnegie Endowment for International Peace, 1979.

4. **Summary:**
   This article discusses the recent emphasis on verification as demonstrated in the amendment to the United States' Arms Control and Disarmament Act. The Act was amended in 1977 in order to include a requirement for adequate verification capabilities - previously, no specific reference was made in the Act itself to verification. The author believes there is an undue emphasis on verification arising from a tendency to pursue effective verification as an end in itself. A concern for verification may also be employed as a means of obstructing arms control agreements. The discussion centres around the "unrealistic" attitude of Congress that verification is an indispensable element of any arms control agreement, and that verification capabilities are never wholly adequate. These assumptions are challenged by citing instances where verification is not the single most important aspect of an agreement. For example, a comprehensive nuclear test ban treaty was prevented by disagreement over on-site inspection, yet national technical means of verification would have sufficed in this instance, given quite good detection and identification capabilities. The author points to successful agreements which made little or no provision for verification, and contends that any problems which have arisen are not attributable to the inadequacy of verification.

Proposal Abstract J5(G78)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International exchange of information
   (c) International control organization - ISMA

3. **Source:**
   France. "Proposals of France for inclusion among the final draft documents (declaration, programme of action, machinery for negotiations) of the special session of the United National General Assembly devoted to disarmament". Preparatory Committee for the Special Session of the General Assembly devoted to disarmament, A/AC. 187/105, 23 February 1978.
   See also: - A/S-10/AC.1/7, 30 May 1978.
   Note: - General Assembly Resolution of 14 December 1978 (A/RES/33/71J) requested the Secretary General to undertake a study of the technical, legal and financial implications of establishing an International Satellite Monitoring Agency (see abstract J11(I81)).

4. **Summary:**

   In the February document, the French representative stated:
   France considers that the international disarmament effort should benefit from the progress made in the technology of observation by satellite. Information useful for the strengthening of security and trust which can be obtained in this way should be placed at the disposal of the interested states, in accordance with political, legal and technical modalities to be agreed upon by consensus by the international community.
   It therefore proposes the establishment of an International Observation Satellite Agency. The Agency which would be directly responsible to the United Nations, would have as its task the collection (by means which it might possess in its own right as well as others), the organization and the dissemination of data obtained by satellite in fields directly affecting security and the control of agreements.

   At the United Nations Special Session on Disarmament the French government elaborated on its satellite proposal. Because earth observation technology had advanced greatly and further progress seemed likely, it is important to place this new monitoring technology at the service of the international community for supervision of arms control agreements and for strengthening international confidence. In addition to monitoring arms control undertakings, the information gathered by observation satellites could provide essential elements

for settling disputes between states by permitting more satisfactory assessment of the facts which give rise to such confrontations.

The French note outlines several guiding principles for the International Satellite Monitoring Agency (ISMA). Its role would be to collect, process and disseminate information secured by satellites. There would also be a provision in its charter to ensure that information collected by the Agency would be used only for the performance of its tasks.

The functions of the ISMA would include, first monitoring implementation of arms control agreements and, second, investigations of specific situations. Regarding the first function, a survey of arms control agreements already in force would be made in order to determine the extent that satellite monitoring could apply. If it was found to be applicable to an agreement the Agency would offer its services to the parties. In the case of future arms control and security agreements the Agency might prepare standard clauses for inclusion in such treaties. Provision might also be made for regional international organizations to solicit the Agency's services.

Regarding the second function of the ISMA, a state could report to the Agency when it felt its security jeopardized by another state. The Agency would then obtain permission from the state to be investigated before proceeding with any investigation. The Security Council might also take action under Article 34 of the United Nations Charter in such a situation.

France proposes that the ISMA be part of the United Nations system as a specialized agency. Membership of the Agency would be open to any state member of the United Nations or specialized agencies. Organization of the decision-making and deliberative bodies of the Agency would include a plenary organ as well as a restricted organ having balanced representation from all regions of the world. The Agency staff would include the technical personnel needed to process and analyze the data collected.

Because of the complexity and costliness of satellite observation, France suggests that the technical resources of the Agency be gradually expanded as the functions assigned to the ISMA grow. Consequently, to begin with, the ISMA would rely on data provided by states already possessing observation satellites. To ensure autonomy of the Agency, it should possess an independent capacity to interpret the data received.

France suggests that there be three stages to the expansion of the Agency:

Stage 1 - a centre for processing data supplied by states having observation satellites,

Stage 2 - data receiving stations to be directly linked to the observation satellites of those states, and

Stage 3 - ISMA observation satellites.

Financing of the ISMA should come from several sources: mandatory payments, voluntary payments, and funds paid in return for Agency services, especially for monitoring arms control agreements.

Some means of settling disputes between the Agency and states or between states should be provided in the ISMA charter. France suggests an arbitration committee be established.

Proposal Abstract J6(A80)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   Jakhu, Ram S. and Ricardo Trecroce. "International Satellite Monitoring for Disarmament and Development". Annals of Air and Space Law vol.5 (1980): 509-527.

4. **Summary:**

This article considers in detail the nature, scope and purpose of the proposal for an International Satellite Monitoring Agency (ISMA). In view of the seriously destabilizing effects of nuclear weapons proliferation, it is argued that some form of arms control would be beneficial. An ISMA is offered as an appropriate means of verifying an agreement - "the most desirable means of verification would be one which is independent and international, controlled and arranged by the international community because of the common interests involved" (p.522).

An ISMA would employ the most sophisticated technology available for satellite monitoring. An advanced system would consist of remote sensing through photography, infra-red and radar sensors assisted by ground stations equipped with sophisticated computer systems for the interpretation of data. The surveillance and warning systems of the superpowers "have focussed on photographic reconnaissance with smaller scale programmes in electronic reconnaissance, ocean surveillance, early warning and nuclear explosion detection satellites" (p.512).

Using a combination of these verification techniques, an ISMA could thus monitor compliance with an arms control agreement. The use of sanctions and international public censure would also be facilitated by the wealth of information provided by an ISMA. The various purposes which such an agency might serve are enumerated:
(1) reassurance and confidence-building to encourage future agreement;
(2) verification of compliance with international agreements;
(3) surveillance as a deterrent to violations;
(4) conflict anticipation for preventive diplomacy;
(5) early warning of preparation or possible attack;
(6) evidence of aggression for adjudication;
(7) monitoring of cease-fires and demilitarized zones; and
(8) communication with international observers (p.513).

The creation of an ISMA is dependent upon the resolution of certain political, economic and legal problems. The political will to carry out this plan is of paramount importance. Initial reactions of

nations have been mixed, ranging from 'unconditional support' to 'outright rejection'. Some foreseeable difficulties included the prohibitive cost, the scope of the data to be collected, legal questions about access to the data, and the status of the nations under observation. Finally, two states - Cuba and the US - were opposed to an ISMA. The US claimed that the proposal was not viable due to "overwhelming political, organizational, technical and financial difficulties", and that irresolvable disputes would arise over judgments about compliance. While the effectiveness of verification is a major concern for the US, some other explanations for their reluctance may also be postulated. The cost of the program will be considerable, and an ISMA may also jeopardize the present dominance of the US in satellite technology.

Cuba clearly stated that any sort of monitoring must not constitute an "interference in the internal affairs of states". Their primary concern was that a nation must give prior consent to such activities in order to preserve sovereignty. This response was significant in that it served to illuminate the opinion of countries who had remained mute on the issue, such as the USSR and other Warsaw Pact states.

There are also some legal issues which must be resolved prior to the establishment of an ISMA. The Soviet Union's contention that surveillance satellites are illegal is rejected as untenable in light of their own use of satellites and the acceptance of national technical means of verification in the SALT agreements. The most vexatious legal problem identified is the difficulty of regulating the dissemination of data. It is asserted that guidelines would have to be established and possible criteria are discussed. Perhaps sensed states should give consent before pertinent information is communicated to other states. Under exceptional circumstances, such consent would not be required, however; for example, "where the Security Council has reason to believe that disarmament agreements are being violated or that a particular conflict situation requires verification or surveillance by ISMA" (p. 525).

Proposal Abstract J7(A80)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellites
   (b) International control organization - ISMA

3. **Source:**
   Thirty-Fourth Pugwash Symposium. "An International Agency for the Use of Satellite Observation Data for Security Purposes". Report from the Symposium held 14-17 April 1980 in Avignon France. Pugwash Newsletter 17, no. 4 (April 1980): 89-97.
   See also: - "Using Military and Civil Satellites to Keep the Peace". Impact of Science on Society 31, no. 1 (1981): 113-122.

4. **Summary:**
   At present information from earth observation satellites is collected and processed by the USSR and the US and this technology has played an important role in the verification of bilateral arms control agreements between these two states. The potential usefulness of this technology to the international community as a whole is great - in the field of verification of multilateral arms control agreements, in supporting UN peacemaking and peacekeeping efforts and in the field of international crisis management on a local or global basis. It also has great importance in the economic and social fields. Several other countries now have the capability to operate earth oriented data acquisition systems and more will follow within the next five to ten years.
   Technological Aspects:
   (1) Background Technology: A number of technologies currently available in several industrialized countries without recourse to either superpower can be integrated into a total information delivery system within reasonably short order, given the resources and will. A development and test period of five to seven years appears sufficient for initial deployment.
   (2) Particular Techniques and Their Application:
       (a) Panchromatic optical digital imagers with resolutions of some three metres can be used in daylight.
       (b) Infra-red optical sensors with resolutions of approximately 50 metres, complement the above and can operate at night.
       (c) Imaging microwave systems (radar) with resolution of 10 metres, provide all-weather day-night observation.
       (d) Non-imaging radar used in the altimetry mode can build up three-dimensional models of terrain.

(e) Satellite-based ground sensor interrogation, location and relay systems continually reporting to a central station are feasible. Ground sensors could be fixed or mobile.

(3) Trade-offs:

It is necessary to trade-off different technical capabilities.

(4) Applicability to International Security Enhancement:

(a) Sensors of the above types can provide reasonably unambiguous data on significant facilities representing relatively slow changing capabilities and can monitor rates and direction of changes.

(b) Movement of men and material can be observed with low ambiguity when traffic is concentrated and directional.

(c) The existence and location of relatively static forces or material stocks may be observed but probably not measured without significant ambiguities.

(d) Many classes of events and items of international security interest are not observable from space although circumstantial activities may be. Among these non-observable events are normal industrial processes in existing indoor facilities, infiltration of men, and the purposes of generally used vehicles or facilities. In addition, countermeasures (camouflage and deceptive actions) can defeat satellite observation.

(5) System Concept:

(a) Space Segment: Three spacecraft each carrying a different type of sensor would be the most efficient mode. The satellites would have angular manoeuvreability and altitude change capabilities but would be unable to change their plane.

(b) Ground Segment: This would be composed of a secure data acquisition, processing and disseminating centre. Some back-up systems may be needed in certain circumstances.

(c) Operational Characteristics: Operations would cover static situations, slow rate of change situations and rapidly evolving situations. From notification to initial output of the system, the time span is estimated at two to three days.

(6) Technical Development Forecast:

In the next 20 years several technical improvements (see source) will occur which will allow improved observation capabilities. The design, development, testing and execution of a new satellite system takes five to seven years. The second generation of satellites should duplicate the first to ensure continuity of operations. The third generation should be subject to a review of experience achieved so far and of new technologies.

Costs:

Costs are estimated as follows:

- Space segment $1 - 1.5 billion,
- Ground segment $200 million,
- Running costs $150 million per annum.

Role and Functions:

The data acquired by the satellites should be made available under agreed rules and procedures in accordance with the UN Charter. Several applications are foreseen for the data including verification of compliance with arms control agreements. Some participants in the symposium maintained that satellite observation is useful in strategic arms limitation when the parties do not camouflage their activities, while for many tactical situations confusing detail would make satellite data of limited value. Most did not share such views but, nevertheless, agreed that the satellite system could not itself provide answers to all the problems. The system should be considered within a wider network of arrangements designed to promote confidence and security.

Constitutional Considerations:

Most participants felt it desirable that the satellite system be part of the UN, some feeling that an internal organ linked to the Security Council had the best chances of enlisting the cooperation of the superpowers. Two other models include:

(1) the Western European countries taking the initiative, with more countries joining later, and

(2) a group of "neutral" countries operating the system. Even without superpower assistance the satellite system could be developed.

Political and Legal Considerations:

Each state or group of states has the right to acquire information necessary for its security by any means permitted under international law. The international community, despite periodic opposition, has more or less accepted the existing situation as far as military and earth resources satellites are concerned. Dissemination of information, however, poses special political and legal difficulties. These relate principally to the sensitivity of the data, its safe storage and confidentiality, and its objective interpretation and fair dissemination.

Proposal Abstract J8(A80)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Tsipis, Kosta. "Technical, operational and policy considerations and alternatives for the use of satellite observation data for security purposes". Cambridge, Mass.: Massachusetts Institute of Technology, Department of Physics, March 1980. (Mimeographed).

4. **Summary:**

Satellites with reconnaissance capabilities could be used for several missions including:

(1) verification of compliance with international agreements,
(2) reassurance as an inducement to enter into agreements,
(3) surveillance as a deterrent to violations of agreements,
(4) attack warning/conflict anticipation for preventive diplomacy,
(5) evidence of aggression such as border violations for adjudication,
(6) monitoring of demilitarized zones and cease-fires, and
(7) communication with international observers.

Such a crisis management satellite network could be applied to several adversary situations. The system would consist of one or more satellites capable of acquiring, storing and transmitting ground imagery at optical wavelengths and possible side-looking radar imagery. Sensor complement, resolution and orbital parameters would be dictated by operation requirements. Memory capacity, rate of transmission to ground stations, and image interpretation and dissemination procedures would be influenced by receiver locations and the emphemeral nature of targets. There is no question such a satellite system is technically feasible at present.

The system has three main parts: the satellite, the sensors and electronic links to and from the sensors, and the receiving and processing ground station. Technical aspects of these components are considered by the author in some detail. A number of questions and key policy implications are then discussed, including:

(1) Will imaging be performed routinely or only under exceptional circumstances? Routine monitoring could collect a great deal of information unrelated to the mission of the system and thus raise political problems.
(2) Will the satellite image all terrain it overflies, or only a few areas per orbit? The former approach will increase technical demands on the system.
(3) Will the data be unencrypted and in real time? Real time unencrypted data could lead to charges of violation of state privacy.

(4) Should satellite manoeuvres and sensing of first approved by an international body or should national agencies be permitted to perform these functions on a time-sharing basis? National access could reduce time available to any particular nation and raise possibilities of abuse of the system.

(5) In what form will the data be disseminated: how extensively will the data be interpreted before disseminated? Raw data would provide high confidence but the burden of interpretation would penalize underdeveloped states.

(6) To whom and under what circumstances should data be disseminated? Public dissemination could cause political problems. Dissemination only to parties in a dispute would protect privacy.

Each satellite might cost about $100 million (US, 1977) while a monitoring station would cost less than $10 million per annum. Administrative costs would be about $7 million per annum.

Several organizational structures for the monitoring satellite agency are presented and discussed including:

(1) a two-component organization consisting of an International Verification Laboratory (IVL) and an international body of mediators to authorize imaging and dissemination of data,

(2) unrestricted sale of imagery by the IVL, or

(3) open-channel real-time telemetry receivable by anyone with a receiver.

Several possibilities for organizational sponsorship are also discussed including:

(1) international sponsorship such as by the UN,

(2) neutral nation sponsorship, and

(3) unilateral great power sponsorship.

Proposal Abstract J9(G80)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Nuclear weapons - proliferation

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Complaints procedure - consultative commission

3. **Source:**
   (a) United States. Arms Control and Disarmament Agency. Annual Report: 1979. Washington: US Government Printing Office, March 1980 (pp. 25-28).
   (b) United States. Arms Control and Disarmament Agency. Annual Report: 1980. Washington: US Government Printing Office, April 1981 (pp. 21-65).

4. **Summary:**

The requirement for adequate verification is clearly stated; this is the requisite standard whereby monitoring capabilities must be able to detect those evasions which pose a significant military risk. National technical means of verification are the central verification measure for this purpose, and SALT II facilitates this process by prohibiting concealment measures, telemetry encryption and interference with verification. The Standing Consultative Commission (SCC) also provides a forum wherein compliance issues may be resolved.

It is noted that the information provided by verification is judged according to a number of criteria, and it is stressed that the degree of adequacy is not based on trust, but rather depends on the weight of evidence. The verifiability of an agreement is determined prior to any negotiation, and is not tailored to Soviet demands or bargaining pressures. However, it is acknowledged that any judgment on the adequacy of verification must take into account current and future intelligence capabilities, Soviet ability to evade detection, and the US ability to respond to violations.

One section of the 1980 report (pp. 21-65) looks at the utility of International Atomic Energy Agency (IAEA) safeguards in providing assurance of compliance with certain restrictions on nuclear materials. As such, these safeguards are an important verification tool which must not be underestimated. They are fairly comprehensive provisions which "combine the maintenance of detailed accounts and records regarding the location, quantities, form and movement of nuclear materials with actual on-site inspection by IAEA inspectors" (p. 21). They are designed to detect the diversion of nuclear material in a timely manner so that nuclear proliferation might be prevented. The US has consistently sought to promote the effectiveness of the IAEA through financial and personnel support, and has also attempted to encourage the voluntary participation of other nations in its safeguards program.

Proposal Abstract J10(A81)

1. **Arms Control Problem:**
Any arms control agreement

2. **Verification Type:**
(a) Remote sensors - aerial
- satellite
(b) International control organization - ISMA

3. **Source:**
Kahane, A. "Is There a Place for Airplanes in a UN Satellite Monitoring Agency?" In Proceedings of the Thirty-First Pugwash Conference on Science and World Affairs, pp. 210-211. London: Taylor and Francis, 1981.
See also: - France. A/S-10/AC 1/7, 30 May 1978 (see abstract J5(G78)).

4. **Summary:**

The author proposes the use of airplanes for monitoring international disarmament or security agreements until an International Satellite Monitoring Agency (ISMA) can acquire satellites of its own. In 1978, France proposed a three stage plan for establishing an ISMA. In the first two stages, the ISMA would acquire information from national satellites and in the third the ISMA would launch its own satellites. Kahane believes that the United States and Soviet Union will not make their military satellites, the only ones with sufficient monitoring capabilities, available to an ISMA, therefore airborne reconnaissance is necessary until the UN can acquire its own satellites. The UN could buy or lease airplanes and thereby initiate ISMA operations long before acquiring satellites.

The use of airplanes is technically feasible. Airplanes fly lower than satellites so that the camera technology required is less complicated and more readily available. Selective flight patterns and revisit schedules can be designed and data can be more easily retrieved than from satellites. Airplanes would cost less than a global satellite system if used for regional surveillance.

There might be legal obstacles to overflights by surveillance planes since overflying is illegal without the permission of the country observed. However, Kahane points out that "once a nation has accepted the principle of UN overhead monitoring...the legal distinction between satellites and airplanes becomes unimportant" (p. 210).

Proposal Abstract J11(I81)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International exchange of information
   (c) International control organization - ISMA
   (d) Complaints procedure - consultation and cooperation
   - referral to arbitration tribunal

3. **Source:**
   United Nations. Secretary General. "The Implications of Establishing an International Satellite Monitoring Agency". A/AC.206/14, 6 August 1981.
   See also: - France, A/AC.187/105, 23 February 1978, abstract J5(G78).
   - United Nations. Secretary General. "Monitoring of disarmament and strengthening of international security". A/34/374, 27 August 1979. (Compiles responses received from member states concerning the ISMA proposal).

4. **Summary:**
   This report prepared by a group of governmental experts examines the technical, legal and financial implications of establishing an International Satellite Monitoring Agency (ISMA) to monitor arms control agreements and international crises. The report comes to four conclusions:
   (1) Satellite monitoring could make a valuable contribution to verifying certain arms control agreements, to preventing or settling international crises and to confidence-building among nations;
   (2) Satellite observation of arms control agreements and for crisis monitoring is technically possible and feasible;
   (3) There are no obstacles in international law or in space law to prevent the establishment of an ISMA;
   (4) Depending on the technical options chosen, the cost estimates for an ISMA would vary within a broad range. Whatever the choice, the cost of an ISMA would be less than 1 per cent of the total annual expenditure on armaments.

   Chapter 1 considers the technical implications of an ISMA. Currently, only the United States and USSR have operational satellite reconnaissance programmes. China is reported to have an advanced satellite capability and France, India and Japan have the potential to develop and launch remote sensing satellites designed for Earth resources surveying. The European Space Agency (ESA) is also developing remote sensing programmes. The report reviews the

satellite capabilities of the various nations. Sensors on American military satellites can obtain ground resolutions of between 0.15 m and 0.3 m which is sufficient to perform most tasks in treaty verification and crisis monitoring (see table 1, p. 30). The Soviet Union has also reportedly developed and deployed military satellites for earth observation and reconnaissance, for electronic reconnaissance, early warning and surveillance of nuclear explosions. The report discusses the limited information available on those satellites.

Satellite data receiving and processing are planned for or have already been established in nineteen countries. Trends in remote sensing technology point to the improvement of capabilities to the point that civilian satellites will have capabilities close to those of military satellites.

The report makes an estimate of the technical requirements for monitoring and discusses monitoring limitations of an ISMA for nine existing international arms control agreements. While it may be difficult to identify from space chemical and biological agents and activities related to their use, an ISMA could observe "characteristics of specialization" associated with special personnel and protection measures in violation of the Geneva Protocol (1925). Development of satellite technology could also work toward a capability for monitoring environmental chemical pollution using advanced spectroscopic equipment. Area surveillance and close-look satellites could detect military activities prohibited by the Antarctic Treaty of 1959 (see abstract B7(T59)). Satellite photography of preparatory activities on the ground for nuclear tests and measurement of radiation from a test contribute to verification of the 1963 Limited Test Ban Treaty (see abstract J120(T63)). It is technically feasible to identify precisely the pay-loads of orbiting satellites and in particular the presence of nuclear weapons on satellites by close-look inspection or fly-bys of satellites, but the cost of systems to perform these functions would be extremely high and existing Earth observation satellites cannot perform these tasks. Thus verification of the 1967 Outer Space Treaty (see abstract B24(T67)) is difficult. An ISMA could, however, contribute to verification of the 1967 Treaty of Tlatelolco (see abstract D1(T67)) by providing photographic coverage of preparatory ground activity for possible nuclear tests. An ISMA could conduct surveillance of construction of nuclear facilities, nuclear test preparation or testing as a supplement to the IAEA safeguards system for verifying the 1968 Non-Proliferation Treaty (see abstract D9(T68)). The 1967 Sea Bed Treaty (see abstract B30(T71)) would appear to be unverifiable by an ISMA. Verification of the 1972 Biological Weapons Convention (see abstract O12(T72)) could be facilitated by space surveillance enabling identification of training experiences of an army or munitions testing related to biological warfare. However, such identification would be difficult. The 1977 ENMOD Convention (see abstract O19(T77)) is not verifiable from space, but satellites could monitor gross environmental changes on the surface of the Earth even if they could not identify the causes of such changes.

The report suggests that a future convention prohibiting chemical weapons could, "to a certain extent" (p.28), be verified by using monitoring satellites. Data requirements and monitoring limitations would be similar to those for the Geneva Protocol (pp. 23-24) and the Biological Weapons Convention (p. 27). A comprehensive test ban treaty could also be verified with the same limitations as the Limited Test Ban Treaty (pp. 24-25). A nuclear-weapons-free zone could be verified in the same way as the Treaty of Tlatelolco. An ISMA could also assist in monitoring disengagement agreements and international crisis monitoring.

The report analyses the technical facilities needed for an ISMA in three proposed phases. In Phase 1, the ISMA would process and disseminate information and data made available by states operating surveillance satellites. Phase 1 would thus entail the construction of Image Processing and Interpretation Centres (IPICs). A data processing subsystem would convert photographic and cartographic data into digital data. Data managing and analysis subsystems would further process and interpret the information. In Phase 2, an ISMA would develop its own ground receiving stations. In Phase 3, an ISMA would acquire its own satellites and utilize the launching capability of other states.

Phase 1 would be a useful training period for ISMA personnel. In Phases 1 and 2 an ISMA would be dependent upon the cooperation and goodwill of member states in supplying information from military satellites (low resolution images from civilian satellites would not be useful for an ISMA). Difficulties may arise as a result of conflicting requests from ISMA and from national bodies addressed to national space systems. Therefore, it would be important for an ISMA to have satellites of its own. A space system could be developed by ISMA itself or acquired from countries with space technology. Success in this phase is dependent upon a number of "uncertain factors" (p. 50).

Chapter 2 considers the legal implications of establishing an ISMA. After reviewing the international legal regime governing outer space activities, the report concludes that there are no provisions in general international law, including space law, which prohibit an international organization from carrying out satellite monitoring activities. No formal protests are known to have been made concerning satellite observation by the US and USSR. The chapter also examines the legal implications of verification provisions of nine existing arms control agreements. The Antarctic Treaty is verifiable by "national means" of verification under Article VII. The Partial Test Ban Treaty contains no verification provisions, but parties could call on an ISMA for verification without modifying or amending the Treaty. The Outer Space Treaty provides for states to verify implementation by their own national means, but states could involve ISMA in the verification process. Reference to "appropriate international procedures" in the Moon Treaty (see abstract B26(T79)) would presumably cover verification by an ISMA. Verification by an ISMA

might also aid verification of the Treaty of Tlatelolco. That Treaty establishes a permanent supervisory organ for verification (OPANAL) which is empowered to "enter into relations with any international organization or body" (Article 19.2).

Verification of the NPT by ISMA would probably require amendment of the Treaty because the IAEA is the only international body specifically authorized to carry out verification. While space surveillance probably could not detect violations of the Sea Bed Treaty, an ISMA could qualify as an international agency "within the framework of the United Nations" and thus act on behalf of states to verify the Treaty. There are no provisions for verification in the Biological Weapons Convention and it is unclear whether violations could be detected from space, but involvement of an ISMA in the verification process would probably not require an amendment of the Convention because the Security Council could call upon an ISMA to assist it in investigating a specific complaint in accordance with Article 34 of the UN Charter. The ENMOD Convention, like the Biological Weapons Convention, contains no provisions for verification, but consultation and cooperation including the "services of appropriate international organizations" (Article V(2)) could involve an ISMA.

The report also suggests a possible role for an ISMA in monitoring future arms control agreements, specifically a comprehensive test ban treaty, a chemical weapons convention, a convention prohibiting radiological weapons and treaties establishing nuclear-weapons-free zones.

The report also looks at the fundamental principles upon which an ISMA would be based and the legal status of an ISMA. The consensus of the group of experts was that the ISMA should be an independent body with close links to the United Nations in order to attract a large membership. Various options are considered concerning the dissemination of data and/or information, the question of access to ISMA data and reports and the initiation of ISMA action.

In case of disputes over the validity of acts of an ISMA, the report suggests that machinery for dispute settlement could be modelled on that used by the European Space Agency (ESA). Article XVII of the ESA Convention provides for disputes which are not settled by the Council to be submitted to a three member arbitration tribunal. Each party nominates an arbitrator and the two arbitrators choose a third. Decisions of the tribunal are binding. Initially, according to the Convention, disputes relating to the ESA should be settled by direct consultations between the parties.

Chapter 3 focusses on the financial implications of an ISMA. Since a variety of technical options are possible, cost estimates are difficult to make. Various groups arrived at different cost estimates, but the report suggests some approximate costs. Establishment of the IPICs in Phase 1 would cost approximately 3 million dollars (1980) and operational costs would amount to 25 to 30 million dollars per year. In Phase 2, a global system of 10 stations with data links would cost 60 to 80 million dollars to establish and

about 20 million dollars annually to run. In Phase 3, launching and operating a single low-altitude manoeuvrable satellite would cost approximately 1.5 billion dollars spread over a ten year period. With a launching every two years, satellite renewal and systems management would cost approximately 120 million dollars per year.

The report also contains maps and charts on Landsat ground stations and Earthnet observational satellites. An annex contains verification clauses contained in existing agreements in the field of disarmament and arms control.

Proposal Abstract J12(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   Abdel-Hady, M. and A. Sadek. "Verification Using Satellites, Feasibility of an International or Multinational Agency". In Outer Space: A New Dimension of the Arms Race, pp. 275-295. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**

This article examines the feasibility and implications of establishing an International Space Monitoring Agency (ISMA) as proposed by France in 1978 (see abstract J5(G78)). The author reviews the issues examined by the Governmental Expert Group established by the 33rd session of the UN General Assembly in 1978 (see abstract J11(I81)). The Group considered questions concerning the international legal status of an ISMA; initiation of ISMA action; acquisition, use and dissemination by ISMA of data (raw, primary imagery) and/or information (processed data); confidentiality of data processing, formating and archiving; and access to ISMA data and reports.

Various possibilities for the legal status of an ISMA were proposed by the Expert Group. An ISMA could be established: (1) as a specialized agency of the United Nations; (2) as a subsidiary organ of the General Assembly; (3) as a subsidiary organ of the Security Council; and (4) as an independent organization outside of the UN system. The last option was not strongly supported by most members of the Group.

Possible sources for initiation of ISMA action could be: (1) a principal organ of the United Nations; (2) an intergovernmental organization; (3) a member of an ISMA; (4) non-member state(s); and (5) parties to an agreement providing for international monitoring. The Group was unable to reach a unanimous decision on the issue of confidential handling of primary satellite data and therefore decided not to recommend a solution to this problem. There is a debate over the appropriate degree of "openness" concerning data handling. A large degree of openness would permit scrutiny of the Agency to ensure that it operates in an impartial fashion. However, the sensitive nature of some of the data may require its safeguarding in the opinion of some states. The question of impartiality also affects the issue of dissemination of data and/or information.

ISMA reports containing only raw data, without any interpretation by the Agency, would promote confidence in the impartiality of the findings, but this information would be useless to those countries which do not possess the ability to interpret the data. It would therefore be advisable that an ISMA prepare factual reports based on the processing and analysis of available data. In cases of inconclusive interpretations, more than one analysis should be provided. Access to ISMA reports could be granted to: (1) all members of the United Nations; (2) only members of the Agency; (3) the Security Council, the executive organ of the Agency and states directly concerned (e.g. parties to a dispute); or (4) only states directly concerned and the executive organ of the Agency.

Technical aspects of establishing an ISMA included consideration of recent developments in satellite technology. An international monitoring agency would use photographic reconnaissance satellites which are capable of a ground resolution of 25 cm. Computer enhancement techniques can improve the delineation of objects under observation. Military surveillance satellites can make an important contribution to the verification process. An ISMA would rely, particularly during its early stages of operation, upon data supplied by other national satellite systems of cooperating space powers.

Cost estimates of establishing an ISMA are difficult to make since there are many possible system designs. However, the author suggests some approximate costs for the three phases of establishing an ISMA specified by the Expert Group. Figures quoted are in 1980 prices. In phase 1, an ISMA would operate as an Image Processing and Interpretation Centre (IPIC). The cost of acquiring data processing and interpretation systems would be approximately $8 million. Operating costs for phase 1 would be in the range of $25 million to $30 million per year. In phase 2, an ISMA would acquire and operate its own ground receiving stations for receiving data. An ISMA system of ten stations with data links would cost approximately $60 million to $80 million to acquire and $20 million per annum to operate. Costs might be reduced if member states made space systems and/or receiving systems available to the agency. A three satellite system for area monitoring which could be acquired in phase 3 would cost between $0.9 billion and $1.2 billion and operational costs would range from $50 million to $200 million per year. A single low altitude manouevrable satellite for "close-look" observation would cost about $1.5 billion for research and development, launching and operating over a ten year period. Satellite renewal and systems management for a launching every two years would cost roughly $120 million per year.

Neither the US nor the USSR supported the French proposal for an ISMA. It is thought that this opposition is based on concern about the balance of information-gathering systems between those two countries and fears of dissemination of vital classified data. However, a change in the American attitude may occur for the following reasons. The US may decide that its strategic interests would be served by the release of information on certain areas of the world, such as the Soviet-Chinese border, through an ISMA. The US may not want an ISMA dominated by French and European technology. An ISMA

might also be valuable for controlling a profusion of national satellites as more countries acquire this capability. The Soviet Union, however, is strongly opposed to the establishment of an ISMA.

The Governmental Expert Group concluded that there were no technical or legal obstacles to the establishment of an ISMA. Despite the wide range of cost estimates, an ISMA would cost less than one percent of the total annual expenditure on armaments.

Proposal Abstract J13(A82)

1. **Arms Control Problem:**
Any arms control agreement

2. **Verification Type:**
Remote sensors - satellite
- radar
- ELINT

3. **Source:**
Blair, B.G. "Reconnaissance Satellites". In Outer Space: A New Dimension of the Arms Race, pp. 125-133. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**
Blair traces the evolution of American and Soviet satellites which can be used for arms control verification, crisis monitoring, early warning of attack and weapons targeting. Early warning satellites using infra-red thermal sensors can detect a missile within a few tens of seconds of launch, but the satellites still suffer from technical limitations. Sunglint and glare from clouds and ocean surface can trigger false alarms or create blind spots in surveillance. Computer and communications malfunctions also inhibit their effectiveness. New technology in satellites such as charge-couple devices (CCDs), mosaic sensors and advanced cryogenic coolers will eliminate many of these technical constraints on satellite capabilities in the 1990s. CCDs are a form of integrated circuit technology. They can process and store signals from a detector that is functionally separate, serve as an integral component of the detector itself or integrate both functions. Charge coupling shifts an electrical charge from one detector element to the next. These versatile devices will allow more signal processing on board satellites, thus reducing the need for ground processing stations, and will permit the deployment of smaller, simpler satellites which are less vulnerable to attack.

Photoreconnaissance satellites such as the US Big Bird and KH-11 satellites are capable of sufficient resolution to detect and identify objects smaller than 30 cm from a height of 185 km or more. 'Close look' and area surveillance cameras can detect and identify most military targets. The trend in the future will probably be toward greater use of multispectral scanners which translate images into digital data. NASA's Landsat satellites use a scanner which operates in four different bands of the light spectrum, three in the visible light spectrum and one band in the infra-red.

Space-based radar using a technique known as side-looking synthetic aperture radar (SAR) with a high resolution capability may overcome the deficiencies of photoreconnaissance (i.e. inability to

pierce cloud cover and darkness) in the next twenty-five years. SAR takes advantage of the motion of the satellite to overcome the problem that conventional antennae for satellites cause images to have a coarser resolution along the orbital path than across it. Using SAR, Apollo 17 obtained radar images of the moon's surface with a ground resolution of 9 m from an altitude of 111 km. Pictures of the images resembled high-altitude photos. This technology, which is being developed by NASA, may be useful for American ocean surveillance. Some reports suggest that the Soviet Union already has an active ocean surveillance capability. Soviet spacecraft apparently carry active radar in low altitude orbit, but there are conflicting evaluations of its performance.

The current generation of ELINT or ferret satellites, known as 'Rhyolite', which intercept data including military communications and radar signals, have been used to intercept telemetry broadcast by Soviet missiles during tests. A new ferret satellite with a long antenna for telemetry interception is reportedly being developed.

Proposal Abstract J14(A82)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Regional arms control - outer space

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ISMA
   (b) International control organization

3. **Source:**
   Deudney, Daniel. "Space: The High Frontier in Perspective". Worldwatch Paper no. 50 (August 1982).

4. **Summary:**

This paper discusses both civilian and military uses of space. One section (pp. 18-25) examines military satellites used for reconnaissance and surveillance and anti-satellite (ASAT) weapons. Military satellites have been used to monitor compliance with the Nuclear Non-Proliferation Treaty and the Limited Test Ban Treaty. In 1977, the Soviet Union detected through satellite surveillance the construction of a nuclear test site in South Africa. Intense diplomatic pressure on South Africa brought the government to halt the construction. Satellite monitoring of regional conflicts such as the 1971 Indo-Pakistani War and the 1967 and 1973 Arab-Israeli wars has helped the superpowers avoid a military confrontation themselves. The observation powers of these satellites (the US Big Bird satellite, for example) are considerable, probably sufficient to read a licence plate from space.

The author points out that both the United States and Soviet Union oppose the idea of an international satellite monitoring agency (ISMA) as proposed by France in 1978 (see abstract J5(G78)). The United States argues that majority rule in a UN agency would be inappropriate for handling sensitive issues of data interpretation, but both the US and USSR would also prefer to continue to monopolize satellite technology. The author suggests that this opposition may be shortsighted; countries may come to resent being observed and seek to limit or ban such observation by treaty. Another argument against an ISMA is cost (between $1 billion and $2 billion per year). However, the author comments that "if satellite verification of regional arms control efforts is half as successful as it has been between the superpowers, the agency could pay for itself many times over in reduced arms expenditures" (p.20).

Satellites have also contributed to war-fighting capabilities. Geodetic satellites, for example, which precisely measure anomalies in the earth's gravitational field, have facilitated improvements in missile accuracy. Anti-satellite weapons have also been developed.

The author recommends arms control measures to prevent the expansive development of these systems. He warns that "once thoroughly tested, these systems will be an arms control verification nightmare since many orbiting Soviet vehicles or many US fighter planes could harbor satellite killers" (p.24).

Proposal Abstract J15(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Epstein, Edward Jay. "Disinformation: Or, Why the CIA Cannot Verify an Arms Control Agreement". Commentary (July 1982): 21-28.

4. **Summary:**

This article outlines one aspect of Soviet military practice which may impede verification of an arms control agreement. A number of intelligence failures in the United States may be directly attributed to Soviet disinformation tactics; "re-analysis suggested that the Soviet Union had deliberately and systematically misled American intelligence by manipulating and 'biasing' as it is called, the missile transmissions that were intercepted" (p. 21). The Soviet Union deliberately transmitted false information, knowing that it would be intercepted by US intelligence sources. Subsequent analyses were thus based on incorrect assumptions and information on Soviet capabilities. The Soviets also managed to successfully deceive the United States by placing false documents in embassy safes that were regularly searched by the FBI. Finally, a nation may deliver false messages to the enemy via a double agent who "pretends to cooperate with enemy intelligence in order to win its confidence" (p. 23).

In view of the potential impact of such deception, some US intelligence analysts advocate a more centralized 'counter-intelligence authority', an "all source unit, able to piece together information from secret agents, surveillance cameras, and the interception of coded messages and telemetry" (p. 21). It is hoped that this compilation and comparison of data will prevent any one agency from being deceived by Soviet misinformation. Other analysts reject this form of reorganization as being "unnecessary and destructive of morale". This debate within the US intelligence organization remains unresolved; "at the core of the dispute is not merely a jurisdictional struggle over who should test the probity of exotic intelligence, but a powerful disagreement over the vulnerability of American intelligence to deception on matters of vital national security" (p. 22). These divisions tend to undermine the effectiveness of American intelligence, and in themselves may prevent verification of arms control agreements as Soviet deception practices continue.

While deception among nations is not new, it is a real cause for concern as a threat to national security: "In peacetime, though its applications are less obvious, fraud still remains an effective means of altering the geopolitical balance of power" (p. 22). One side may

gain a considerable advantage from such deception. For example, the Soviet Union managed to gain the lead in chemical weapons production by prompting the US to halt their own production of chemical and biological weapons. Soviet double agents Fedora and Top-hat persuaded US authorities that Soviet chemical stockpiles were low, so that the US would gain a unilateral advantage from a freeze in chemical weapons production at that time. "Four years later... US intelligence found that it had greatly underestimated the Soviet capacity for chemical warfare" (p. 22).

It is concluded that Soviet deception has caused US intelligence to gravely under estimate Soviet missile accuracy and force strength. While it is unlikely that such deceptive practices would succeed today, the fact remains that satellites and electronic intelligence are not foolproof; this "continuing vulnerability to Soviet disinformation casts the most serious doubt on whether national technical means can ever be sufficient to verify Soviet compliance with any new arms control agreement" (p.28).

Proposal Abstract J16(A82)

1. **Arms Control Problem:**
Any arms control agreement

2. **Verification Type:**
(a) Remote sensors - satellite
(b) International control organization - ISMA

3. **Source:**
Jasani, Bhupendra, "Satellites for Crisis and Arms Control Monitoring". In Outer Space: A New Dimension of the Arms Race, pp. 105-117. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**
The author proposes establishing an international verification agency to verify disarmament agreements. The agency could direct the development of civilian space technology for use in verification and would enable countries without "national technical means" of verification to participate in the disarmament process. The author notes that developments in space-based remote sensing technology would facilitate the establishment of an international agency. For example, the University of Tokai in Japan has developed an image processing technique which can improve the resolution of images obtained from the US Landsat satellite orbiting at an altitude of 900 km. Similar proposals have been made by prominent personalities and scholars and more recently by France (see abstract J5(G78)).

The author states that civilian space technology in satellite observation is approaching military technology capabilities in many respects. Furthermore, satellite technology, launcher technology, and image processing technology are being acquired by more countries. However, there are problems which must be considered before an international agency could be established. Data from other sources would be necessary to supplement observation from satellites. This could be made possible by involving existing international organizations in arms control verification. The author provides a table listing some international organizations (and their functions) which are potentially relevant to arms control agreements (Table 6.4 pp. 114-115). Another problem is the concern expressed by states about the impact of satellite monitoring on national security. However, the author suggests that once many states possess a satellite observation capability, fears about releasing sensitive data may no longer be realistic.

The chapter contains tables listing satellite launches as of the end of 1981 and Landsat ground stations. Another useful table outlines the contribution from observation satellites to verification

of arms control treaties. For twelve arms control treaties, this table indicates the type of satellite used, the sensors needed for observation and the type of activities which need to be observed. Comments on the usefulness of satellite observation for verification of each treaty are provided.

Proposal Abstract J17(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite
   - ELINT
   - radar

3. **Source:**
   Jasani, Bhupendra. "Military Activities in Outer Space". In Outer Space: A New Dimension of the Arms Race, pp. 41-90. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**

This chapter surveys military activities in space including reconnaissance, surveillance, communications, navigation, meteorology and geodetic surveys by satellite, military use of manned spaceflights and anti-satellite systems. Section II discusses four types of reconnaissance satellites: photographic, electronic, ocean surveillance and early warning satellites. While the Soviet Union uses different photographic satellites to perform area surveillance and close-look missions, the new generation of US Big Bird satellites can perform both functions. New techniques will enable the satellites to convert images into electronic signals which can be transmitted to the Earth so that fewer films will need to be returned. With less equipment on board, more fuel can be carried by the satellites so that there will be a trend toward longer-lived satellites.

Various sensors are used on reconnaissance satellites. These include photographic and return-beam vidicon (RBV) television cameras, multispectral scanners (MSS) and microwave radars. Different sensors have different resolution capabilities. A useful table indicates the resolution required for interpretation tasks. It lists the requirements for detection, general identification, precise identification, description and analysis of various targets ranging from bridges to missile sites to nuclear weapon components. Since estimates suggest that current satellite technology is capable of ground resolution of 15-30 cm, it would be possible for satellites to permit precise identification of nuclear weapon components according to the table.

One figure shows the extent to which the US KH-11 and the Big Bird satellites have observed the Earth since 1977. There appears to be considerable overlap in the coverage of these satellites. It is possible that the Big Bird satellites are used to obtain high quality photographic images of areas which the KH-11 satellites indicate are of special interest.

Electronic reconnaissance satellites are used to monitor radio signals from military communications, early warning radars, air-defence and missile-defence radars or from those used for missile control. They can also collect information on missile testing and new radars.

Ocean surveillance satellites are able to detect the presence of military surface vessels. American ELINT Ocean Reconnaissance Satellites (EORSATs) launched in 1976 will facilitate the identification of surface vessels by Radar Ocean Reconnaissance Satellites (RORSATs) once these satellites are launched and become fully operational. Efforts are being made to develop space sensors which can measure ocean properties such as the height of waves, the strength and direction of ocean currents and surface winds and water temperature in order to assist submarine detection by non-space-based sensors.

Using recent American developments in thermal imaging sensor technology, early warning satellites may be able to detect aircraft and cruise missiles as well as ICBM launchers. Charged couple devices (CCDs) in sensors will be used to monitor launches and aircraft by identifying the infra-red signatures of targets.

The chapter notes that the United States has three operational nuclear explosion detection satellites, the Vela satellites, which orbit at an altitude of 110,000 km. One of these satellites detected what may have been a low-yield nuclear explosion over the sea near the South African coast on 22 September 1979. A US early warning satellite detected a flash in the same region on 16 December 1980, but scientists have been unable to determine conclusively whether the two events were caused by nuclear explosions or natural phenomena. Another American satellite system, the navigation satellite NAVSTAR Global Positioning System, will also be used to detect nuclear explosions in the atmosphere and in outer space within the Integrated Operations Nuclear Detection System (IONDS).

Proposal Abstract J18(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Orhaug, T. and G. Forssell. "Information Extraction from Images". In Outer Space: A New Dimension of the Arms Race, pp. 215-227. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**
   The versatility of imaging sensors makes them useful for arms control verification. Photo image interpretation of information collected by remote sensors is often possible only with sufficient a priori information which permits decoding of brightness values. Digital computers can help in the detection, recognition and identification functions of image interpretation. This paper identifies a special application of computers: the simulation of images having different ground resolutions.

Proposal Abstract J19(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Perry, G.E. "Identification of Military Components Within the Soviet Space Programme". In Outer Space: A New Dimension of the Arms Race, pp. 135-154. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**
   This paper discusses the location and function of Soviet military satellites. The missions of the various satellites include photographic reconnaissance (four generations of satellites are discussed), electronic intelligence gathering, early warning, ocean surveillance, navigation and communications. The resolution capabilities of Soviet photographic reconnaissance satellites are estimated to be 1:3,000,000 on photoscales in the case of Earth-resources photography from Salyut 6 (search-and-find mission), 1:250,000 for quick-look coverage and 1:50,000 or 1:100,000 for close-look missions. It is possible that satellite photographs could show the general outline of small vehicles, such as cars, or even continuous features, such as well-used paths.

   The paper also discusses Soviet work on improving anti-satellite weapons.

Proposal Abstract J20(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - aerial

3. **Source:**
   Rostow, W.W. Open Skies: Eisenhower's Proposal of July 21, 1955. Austin: University of Texas Press, 1982.

4. **Summary:**

The 'open skies' proposal of 1955 is described in detail, both in terms of its impact and its evolution in the political realm. It was essentially a verification proposal which called for mutual access to US and Soviet airspace with the establishment of "ample facilities for aerial reconnaissance". This proposal was put forth by Eisenhower at the 1955 UN Conference at Geneva, and its significance is described in this text as a "a stunning, if transient, psychological and political victory for the United States and its President". This verification proposal was perceived as a bold challenge to the status quo, as the US strove to open "a tiny gate in the disarmament fence" and simultaneously measure the extent of the Soviet commitment.

The development of the open skies idea is traced in this book, and it is noted that its emergence may be attributed mainly to the influence of key political figures or groups. The initial conception grew out of a meeting of the Quantico Panel, of which Rostow was a member. This panel was set up by Rockefeller to investigate policy options for the Geneva summit. It was comprised of academics, military officials, and professionals who were knowledgeable on issues of national security. Together, they arrived at an agreement which would form the basis for the open skies proposal. At its inception it was supported by Rockefeller, and was ultimately advocated by Eisenhower in his address to the UN. Its acceptance as a US initiative was preceded by some 'behind the scenes' power struggles within the US administration, and these are thoroughly elucidated. The political context at that time is also described at a more general level, as shifts in Soviet policy and attitudes are traced. It is noted that the 1955 Conference was remarkable for its attitude of 'relaxed tension'. This is attributed to the Soviet Union's attempts to encourage complacency and allay anxiety among allied nations, without actually working towards peace.

An account is also given of the impact of the open skies proposal. Domestically, it was hailed as a success. It received much international approval, and even the Soviet Union reacted favourably to the initial address. Soviet officials later expressed concern that

the proposal amounted to "nothing more than a bald espionage plot against the USSR" (p.8). The idea was ultimately rejected by the Soviet Union on the grounds that it would not prevent concealment and did not allow for prompt disarmament.

In conclusion, it is stated that this proposal, as one of the earliest efforts to establish mutual verification, was stymied by the Soviet Union's reluctance to move away from the closed society and continued secrecy. The proposal remains as a sound, if limited success for the Eisenhower administration, and was an indication of a genuine desire to move towards disarmament.

Proposal Abstract J21(A82)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite
   - radar

3. **Source:**
   Sakata, T. and H. Shimoda. "Image Analysis and Sensor Technology for Satellite Monitoring". In Outer Space: A New Dimension of the Arms Race, pp. 197-214. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**

This paper covers recent developments in image processing used to facilitate analysis and interpretation. Image processing techniques can be divided into two categories: image correction and information extraction. Image correction involves correction of radiometric errors, geometric distortion caused by the sensor itself and internal and external effects which occur during space flight. Analogue and digital image processing are used to analyse and interpret images. The conventional mini-computer with input and output devices and large scale memory discs is the type of processor commonly used for image processing.

The paper describes sensors and cameras used for satellite observation as well as multispectral scanners, image tubes and synthetic aperture radar (SAR). The advantages of SAR are: (a) it functions under cloudy or rainy conditions; and (b) it can detect small water turbulences. However, its drawbacks are: (a) it has large geometric distortions; (b) the reconstructed image contains "speckle noises"; (c) a lot of processing is necessary to reconstruct images; and (d) the interpretation of images can be difficult. Image tubes have a special structure, a return beam vidicon (RBV), which contains no moving parts (unlike a multispectral scanner) and is lighter than a multispectral scanner. However, the RBV does contain fairly large geometric and radiometric distortions.

The paper lists the resolution powers of the various sensor systems. The total resolving power of space-borne cameras will be in the range of 15-100 line pairs per millimetre (lp/mm). For RBV, the total number of resolved points will be between 1,125 and 3,500 for each line. Multispectral scanners are able to resolve 2000 to 6000 points per line. SAR is capable of a ground resolution of 10-25m. Ground resolution cannot be considered in isolation, however, because an increase in ground resolution reduces the coverage area and increases the required processing time.

Proposal Abstract J22(A83)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA
   (c) International exchange of information

3. **Source:**
   Brzoska, Michael. "Third World Arms Control: Problems of Verification". Bulletin of Peace Proposals 14, no. 2, (1983): 165-173.

4. **Summary:**

The US is no longer committed to the limitation of arms tranfers, and the onus is now on Third World countries to initiate discussion on arms transfer limitations. The central problem here is that Third World countries may reasonably demand that the super-powers should disarm first, yet this is both unlikely and impractical. Consequently, the possible means by which developing nations could implement limitations are considered and some attention is given to the problems of verifying compliance.

Verification is specified as a "crucial and thorny issue" which tends to aggravate any agreement. Currently, only the US and the Soviet Union possess the technical capability to adequately verify an agreement. Their satellites have tremendous resolution and in the future may be able to distinguish people as well as buildings, roads, and military installations. Given this superiority, it is asserted that "no real verification scheme seems possible without the US and the Soviet Union", (p.169) yet Third World countries are reluctant to rely on these data sources. One alternate proposal for an International Satellite Monitoring Agency (ISMA) is put forward, but its effectiveness will be limited by the use of the French SPOT satellite which does not have sufficient resolution for verification purposes. Another serious question which arises is the advisability of a satellite system which provides such extensive information. Not only would it infringe on national sovereignty by providing information on all activities in foreign countries, both military and otherwise, but it might also allow for increased government intervention and control of their own territory as well.

A second means of verifying compliance is through the use of conventional information gathering. Three sources of military information are the Stockholm International Peace Research Institute (SIPRI), the US Arms Control and Disarmament Agency (ACDA), and the International Institute for Strategic Studies (IISS). The former

relies on public sources only, while the latter two use all available sources, including intelligence services. Both are unreliable, however, and the statistics tend to reflect the interests of the organizations themselves.

These difficulties may be overcome in part by a "more modest attempt at building confidence in verification" (p.170). It is suggested that both industrialized and Third World countries should make available their statistics on arms transfer and production. While this would not rule out cheating, it would help to establish a more "authoritative set of international arms statistics" and might help to increase confidence.

Proposal Abstract J23(A83)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) International control organization - ISMA
   (d) International exchange of information

3. **Source:**
   Schear, James A. "Verifying Arms Agreements: Premises, Practices and Future Problems". In The Verification of Arms Control Agreements, pp.76-95. Edited by Ian Bellany and Coit D. Blacker. London: Frank Cass, 1983.

4. **Summary:**

In this general discussion of verification, the author reviews developments in arms control verification, identifies some limitations of current measures and points to three challenges for verification in the future. The author suggests that national technical means of verification are becoming increasingly vulnerable and that acceptance of surveillance is more a product of fear of retaliation for interference than of a real interest in arms control. Verification of Soviet-American bilateral arms agreements has not been matched in multilateral agreements. Furthermore, the political basis for verification has been undercut by Soviet and American arms build-ups.

Technological innovations such as cruise missiles and binary chemical weapons which influence the strategic environment will pose a challenge for verification. Another challenge will come from public demands for effective verification because of uncertainty in the strategic environment. A third challenge will be the product of diplomatic pressure to "multilateralise" the verification process of bilateral and multilateral arms control agreements. Recent efforts in this direction have included the French proposal for an international satellite verification authority and calls for reforms to multilateral consultative and fact-finding arrangements.

Schear concludes that establishing an ISMA would be difficult because it involves consensus decisions taken by a number of states on the collection, evaluation and use of sensitive intelligence information. Establishing an ISMA independently from a negotiated arms control agreement would also work against the view that verification provisions should be directly linked to the design of a treaty. Other proposals might be more worthwhile. For example, a standardised reporting system for defence expenditures, which was developed under UN auspices, could be used to build confidence and

enhance verification using data exchanges. Remote sensing to improve IAEA non-proliferation safeguards should be developed. The United Nations should be given an improved capability to conduct ad hoc fact-finding missions. A staff of scientists and technical experts could help the Secretary-General carry out investigations if requested to do so by parties to an agreement.

Proposal Abstract J24(A83)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Steinberg, Gerald M. Satellite Reconnaissance: The Role of Informal Bargaining. New York: Praeger, 1983.

4. **Summary:**

The book is "less concerned with the technical aspects of reconnaissance satellites or the benefits they bestow on the international system than with the political process that has enabled them to function without interference" (p.3). Part I of the volume is descriptive, consisting of a history of policies and the interaction of the superpowers in the area of space reconnaissance at the beginning of the space age. Part II analyses these events and explores the broader implications of the informal resolution of the conflict described in Part I, on arms control negotiations.

The author concludes that the informal process through which negotiation between the superpowers took place on the issue of space reconnaissance contributed significantly to the result which emerged (ie. tacit agreement to allow space reconnaissance without interference). Moreover, it is apparent that to formally negotiate such acceptance would have resulted in failure. "Thus, from the perspective of a policymaker, the conclusions of this volume indicate that in order to increase the probability of successful restraint of arms completion, the familiar formal process of arms control negotiation should not be the only approach considered" (p.172).

In answer to the question whether the space reconnaissance case is representative of arms control negotiations in general, the author suggests caution. "Acceptance of reconnaissance satellites was accomplished before the physical means to interfere with them were developed" (p.173). "Bureaucratic investment" in space reconnaissance was also relatively limited. In addition, the informal legitimization of satellite reconnaissance essentially confirmed the status quo. Finally, the issue of space reconnaissance was not central to the superpowers' national security.

The role played by the political leadership, especially in the US, was essential. "Centralized control that excludes bureaucratic actors facilitates informal agreements and restraints, but does not guarantee successful resolution of conflict" (p.175).

It seems, according to the author, that in cases where boundaries are sharply defined, as in space reconnaissance, informal restraints

lead to fewer disputes and less conflict than formal agreements. Moreover, it is uncertain whether formal treaties are longer lived and less subject to unilateral abrogation in times of conflict or changing technology. While a formal treaty is more visible, informal agreements are often as durable.

Proposal Abstract J25(A83)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - aerial
   \- satellite

3. **Source:**
   Velocci, T. "Strategic Reconnaissance/Surveillance". Military Technology (October 1983): 18-21.

4. **Summary:**

The author distinguishes between reconnaissance ("a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy; or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area" (p.18)) and surveillance ("the systematic observation of the atmosphere, or subsurface areas, places, persons, or things by visual, aural, electronic, photographic, or other means"). Surveillance systems collect information continuously whereas reconnaissance missions are directed at localized targets.

The author states that the US probably has an edge in the field of strategic intelligence-gathering with the single exception of real-time ocean surveillance satellites. The Soviet Union has two real time ocean surveillance satellites in low earth orbit while the US has no comparable ability, but the overall American superiority is a result of the American Defence Department's ability to process large volumes of data rapidly.

There are two primary technical means of strategic reconnaissance/surveillance (R/S): signal intelligence and imagery. Spacecraft are the heart of American R/S. Real time imagery is possible with radar and television. Film capsules, however, are still ejected for recovery on Earth even today.

Despite the increasing reliance on satellites for R/S there is still a role for manned systems (ie. aircraft) for several reasons:

- Satellites are becoming more vulnerable to attack especially their ground stations, upon which they are very dependent;
- Satellite networks cannot be easily reconstituted if parts are damaged;
- Satellites also have technical limitations such as cloudy weather, rain, and darkness.

It is therefore prudent to have a complementary, back-up R/S capability. Manned systems which are more flexible and less predictable in their movements provide this back up as well as being able to carry certain types of sensing equipment that are not easily installed on spacecraft.

The US relies on three aircraft for R/S: the SR-71 BLACKBIRD, the U-2 and the RC-135. The USSR operates the TU-95 or BEAR-F. Details about these aircraft are provided.

American R/S is evolving in at least two directions. One is an intensive effort to improve the survivability of satellites and their ground stations. The second direction is in the field of advanced remotely-piloted vehicles (RPVs).

Proposal Abstract J26(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA
   (c) International exchange of information

3. **Source:**
   Couteix, Simone. "Les 'satellites bleus' au service de la paix et du désarmement". Problèmes Politiques et Sociaux nos. 480-481 (27 January 1984): 57 - 61. (Originally printed in German Yearbook of International Law 24 (1981): 242-261).

4. **Summary:**

The idea of an International Satellite Monitoring Agency (ISMA) has been advocated for a number of years. In 1972, two American scientists, Bruce Murray and Merton Davies, proposed the idea of international control of satellites under the UN in order to accelerate disarmament and verify ceasefires and demilitarization agreements. In 1975, Abram Chayer, William Epstein and Theodore Taylor, who were associated with the Pugwash movement, suggested the establishment of an international satellite monitoring system which would transmit information through the United Nations (see abstract H48(A77)). The idea of an ISMA gained a forceful advocate when France proposed the idea in the UN in 1978 (see abstract J5(G78)).

Nations reacted to the French proposal in different ways. About a dozen states were in favour of the French suggestion. An equal number supported the idea in principle, but hoped that the problems involved in the proposal would be the subject of supporting studies. Eleven states refused to get involved until the proposal had been studied in greater detail. Cuba rejected the proposal completely on the grounds that "monitoring arms control agreements must not in any way constitute interference in the internal affairs of states". The United States responded negatively also, noting that establishing an ISMA would pose insurmountable political, organizational, technical and financial difficulties. The Soviet Union was conspicuous in its silence in response to the French proposal.

Satellites for surveillance purposes under the control of an ISMA would be regulated by the 1967 Outer Space Treaty (see abstract B24(T67)). Article VI of that Treaty permits international organizations to undertake space activities, including satellite observation, as long as they are for the benefit of all countries (Article I(1)).

There are a number of possible arrangements for establishing the legal nature of an ISMA. The ISMA could be given status as a new specialized agency of the UN or it could become part of the existing UN structure under the auspices of the Secretary-General for example. The French proposal of establishing a separate, specialized agency was preferred by a number of experts and qualified jurists who felt that this arrangement would be the best and would be most conducive to solving technical and financial problems. The design of the agency could be based on the following characteristics:

(1) universality and equality for all participating countries;

(2) a classical structure with a deliberative plenary organ and a decision-making organ with limited powers, with representation not only for countries with advanced technology, but also for all countries based on an equitable geographic distribution; and

(3) guarantees of independence in the performance of its functions.

The technical means for the operation of an ISMA could be established in three phases. In the first phase, an ISMA would operate a data analysis and interpretation centre using data supplied by American and Soviet surveillance satellites. In the second phase, data collection stations would be directly linked to the satellites of those countries (or perhaps European or French satellites at some point). The third phase would see the ISMA acquire and deploy its own surveillance satellites.

Sources of financing for an ISMA could be of three types:

(1) voluntary contributions, especially in kind; for example states could place satellites at the disposal of the agency;

(2) obligatory contributions to the operating expenses of the UN; and

(3) payment for services rendered by the agency, for example monitoring an arms control agreement to which a state is a party.

Due to the scope of the measures associated with an ISMA, the participation of the space powers or at least the large majority of the technologically advanced countries would be indispensable.

If parties do not wish to create a permanent surveillance agency, they could specify conditions for the initiation of limited ISMA activity and the dissemination of data. Action could be initiated on the request of the Security Council, an intergovernmental organization (for regional verification) or a member state (for verification of an arms control agreement).

The biggest problem to be resolved is that of the use of data after it is collected and analyzed. Many states do not wish to submit to satellite surveillance without their prior consent because of security concerns. The release of only raw, unprocessed data is not a satisfactory solution because many states do not have the capability to process and analyze the data. The solution could be to have the ISMA issue reports which translate the data into clear language, but, again, the problem of who would have access to the reports remains. Ultimately, if conceived of as an alert system along the lines of the International Atomic Energy Agency, an ISMA could play a role as a technical agency with neither a political role nor the power to impose sanctions.

 J27(A84)

Proposal Abstract J27(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar
   - aerial
   - ELINT

   (b) On-site inspection - selective

3. **Source:**
   Gilman, Ernest. "Arms Control Negotiations: Verification is the Problem". Canadian Defence Quarterly 13, no. 4, (1984): 8-16.

4. **Summary:**

This article considers the claim that arms control is no longer viable due to the inability to monitor agreements. The author contends that agreement is prevented by political obstacles rather than technical difficulties, and that verification is being used to attack the concept of arms control. The verification process itself is intended to provide security with lower levels of armaments by deterring cheating and enhancing confidence. The level of verification required in a given treaty may vary, ranging from absolute, through adequate (ie. limited) to symbolic (ie. none). Currently, treaties are becoming harder to verify as the Reagan administration now demands more stringent "effective" verification where "adequate" verification used to suffice.

Some of the challenges to verification capabilities are examined in an attempt to determine the adequacy of national technical means of verification (NTMs). The author asserts that NTMs are still a viable means of monitoring compliance, as advancements in surveillance technology have kept pace with most weapons developments. NTMs are comprised of: photographic satellites, electronic reconnaissance and early warning radar, optical equipped reconnaissance aircraft, electronic listening posts, backscatter radars and surface ships which collect telemetry signals. The effectiveness of these verification measures is increasingly being challenged, as analysts fear that satellite capability will be degraded by adverse weather conditions, equipment failure, the contours of the land and the distance and size of the area to be monitored.

It is acknowledged that substantial technological obstacles to verification also exist, as recent generations of missiles tend to be more versatile, mobile and diverse. Miniaturization has made it easier to conceal weapons, while better stealth techniques and remote

guidance may significantly impede monitoring. Finally, weapons testing has become more obscure because weapons like cruise missiles do not require lengthy and elaborate testing.

Despite these problems, "the utility of national technical means to verify arms control agreements in the future may not be as bleak as some believe" (p.11). On-site inspection will be a necessary component of these means of verification, and this in turn demands some break in the "vicious cycle of psychological insecurity". It may be possible to gain Soviet acceptance of on-site inspection, for they have shown signs of increasing openness in recent years. Other nations have been similarly slow to accept intrusive verification measures, and it is thus not inconceivable that the Soviet Union may accept on-site inspection in time.

Finally, there are a number of less intrusive, cooperative means of verification which may provide additional security and help to demonstrate compliance where technical problems have rendered the task of verification more difficult. Among these are the agreement not to interfere with one another's NTMs, the use of mutually acceptable definitions, and "functionally related observable differences" which make different weapons systems readily distinguishable.

J28(A84)

Proposal Abstract J28(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Gregory, William H. "Satellite Intelligence - and Its Limits". Aviation Week and Space Technology (January 16, 1984): 9.

4. **Summary:**
This article asserts that despite recent technological advances, US satellites are currently not capable of providing adequate surveillance to verify an arms control treaty. Resolution in space photography is very good, but there are a number of limitations which prevent the optimal use of this technology. Soviet attempts at concealment demand thorough coverage over a large area at all times, yet "the numbers of reconnaissance satellites the US is flying now are not nearly enough" (p. 9). Presently, the US is not fielding any new film return satellites in its attempts to keep the digital imaging KH-11 satellite program alive. Consequently, the US has fewer operational close-look satellites, and of these, the most advanced cannot operate at night or under adverse weather conditions. It is concluded that a broader, more comprehensive approach to verification and satellite information gathering is necessary.

Proposal Abstract J29(A84)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Nuclear weapons - comprehensive test ban
   - partial test ban
   - missile tests
   (c) Regional arms control - Europe

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ground-based
   - ELINT
   (b) Seismic sensors - international network
   - intra-border stations
   (c) International control organization - ISMA
   (d) Complaints procedure - consultative commission

3. **Source:**
   Jasani, Bhupendra and Frank Barnaby. Verification Technologies: The Case for Surveillance by Consent. London: Berg Publishers, 1984.

4. **Summary:**
   The authors state that "to be both successful and meaningful, arms control must be a universal undertaking" (p.22). They therefore support the establishment of an international verification agency which could use various methods simultaneously to verify arms control agreements. No blueprint for such an agency is offered because of political, financial and organizational problems which must yet be overcome. However, a number of existing international organizations could be relevant to arms control verification or could serve as a model for a future organization. Table 2 (p.111-113) lists these organizations.

   The authors review technological capabilities for arms control verification which include the following systems and equipment.

   (1) Sensors on-board satellites (pp. 26-35):

   Photographic cameras continue to be the best compact sensors for use in reconnaissance missions. There are basically three types of cameras: frame cameras, panoramic cameras and strip cameras. Frame cameras are the most widely used. They have a conventional camera structure but more complex optical components. The capabilities of frame cameras used by the military are not yet known. Plate VI (p. 135) reprints a US military satellite photograph (type of camera not specified) from Jane's Defence Weekly (11 August 1984). The picture shows a Soviet nuclear-powered aircraft carrier in sufficient detail to display the activities of individual servicemen and to permit the observer to read licence plates.

The capabilities of cameras used for civilian purposes are beginning to approach those of cameras used for military surveillance. Military surveillance is capable of obtaining ground resolutions of between 0.2 m and 2 m for close-look and between 2 m and 5 m for area surveillance. In comparison, a US large-format camera intended for launching by the space shuttle in June 1984 can obtain a ground resolution of about 18 m from an altitude of 268 km and 9 m from 130 km.

Photographic equipment must contend with the problem of image distortion due to atmospheric conditions. Distortion can be compensated for before the image is recorded and computer enhancement techniques can improve the quality of images after they are recorded. A new technique using adaptive optical arrays which deform a mirror or lens to compensate for atmospheric distortion is currently being developed.

Multispectral scanners (MSS) have been developed in part to detect the use of camouflage to disguise objects. Camouflage creates a spectral response different from that of natural objects and therefore can be detected by the scanners. There are two types of MSS. The first type uses a combination of a telescope and a rotating mirror. The second, the pushbroom type, uses linear arrays of detectors such as charge coupled devices (CCD). The French SPOT satellite is expected to have a CCD sensor. A new sensor with considerably improved performance, the thematic mapper (TM), has been used on the recent US Landsat 4 satellite. This sensor can produce 'theme maps' which emphasize, for example, farms, forests or urban areas. The TM is capable of greater resolution and a faster rate of data transmission than older MSS. Plates II, III and IV (pp.132-133) show examples of images produced by a TM. Table 4 (p.115) summarizes the characteristics and capabilities of sensors on-board various satellites.

Synthetic aperture radars (SAR), the most powerful non-military radars, have been orbited by both the US and the Soviet Union. These systems have the advantage of functioning in all weather conditions, but their resolution powers are inhibited by the fact that only short antennae can be used in outer space (resolution is, in part, a function of antenna size). The US SIR-A flown on-board the space shuttle in November 1981 and the Seasat 1 satellite which operated briefly in 1978, obtained images with a ground resolution of 25 m. Plate V (p.134) shows an example of the images obtained by the Seasat 1 satellite. Objects such as river barges, highways, airports and railway tracks can easily be distinguished.

Return beam vidicon cameras (RBVs) are essentially colour television which produce video output by scanning images stored on a photosensitive surface. These cameras are sensitive to the visible and near-infra-red part of the electromagnetic spectrum.

Very little is known about electronic reconnaissance by satellites. Electronic sensors gather signals intelligence (SIGINT) which includes electronic intelligence (ELINT) and communications intelligence (COMINT). ELINT is important for arms control

verification because it monitors radio signals generated by military activities involving early warning radars, air defence and missile defence radars, missile control radars and missile testing. The greater field of view obtained from outer space makes it an ideal location to station electronic reconnaissance satellites.

Radiation detectors based in space can detect radiation from nuclear explosions, but face the problem of discriminating between natural radiation, such as Van Allen radiation belts and solar flares, and radiation from test explosions. As a result, techniques to monitor other phenomena are sometimes used. Satellites may carry optical instruments which analyze the emission spectra of chemical elements of a nuclear bomb or its fission products. Sensors which can detect x-rays, gamma rays and neutrons are also used. Optical instruments called "bhangmeters" which detect and record the bright flash from a test explosion in space are used on-board US Vela satellites. Area surveillance satellites can also be used to detect preparations for an underground nuclear test explosion. The Soviet Union detected such preparations by South Africa with Cosmos satellites in July 1977 and informed the United States. South Africa halted its preparations. Existing systems would thus appear to be capable of detecting such a violation of a future comprehensive test ban treaty. Space-based surveillance could observe the subsidence crater created by an underground explosion. Synthetic aperture radars and multispectral scanners could also search for structural and spectral changes on the earth's surface associated with an underground nuclear test. Although there is no evidence to support the claim, it is possible that ELINT is used to monitor electronic signals from a nuclear test.

(2) Satellites (pp.35-38):

About 70 percent of the 2,114 military satellites that had been launched by the end of 1983 were photographic reconnaissance satellites. These satellites take photographs from altitudes between 130 km and 150 km with a ground resolution of about 0.3 m. Soviet satellites must be recovered to obtain films, but the Americans can order the periodic release of film canisters from satellites which are then recovered either in mid-air or from the sea. American Big Bird satellites perform both area surveillance and close-look missions. Area surveillance films are usually developed, converted into electronic signals and transmitted to earth from the satellite. Close-look films with high resolution images, however, are returned to earth for processing and analysis. The latest satellite generation, the KH-11, transmits digital images to the earth in real time. Soviet satellites generally have a shorter lifetime (fourteen days for the majority) than the American satellites (200 days for the Big Bird satellite). Photographic satellites have important functions in searching for new construction of military installations and fixed missile launch sites.

Electronic reconnaissance satellites are launched with Big Bird satellites and are then ejected into a much higher orbit (usually with an altitude of between 600 and 700 km). Satellites launched under the

Defense Support Program, including the Rhyolite series, provided early warning functions as well as nuclear explosion detection. These satellites were thus able to contribute to verification of the ABM and SALT agreements as well as the 1963 Limited Test Ban Treaty (see abstracts J67(T72) and J120(T63)). In addition, other US satellites were deployed specifically to monitor the Limited Test Ban Treaty.

Twelve American nuclear explosion monitoring satellites, the Vela satellites, orbit at an altitude of 110,000 km, but only three are operational. The US navigation satellites, NAVSTAR, will be fitted with x-ray sensors and optical sensors to detect nuclear explosions under the integrated operational nuclear detection system (IONDS). It is hard to identify which Soviet satellites perform the nuclear explosion detection function because the Soviet Union has never declared the nature of the missions of most of its satellites. None of the Cosmos satellites appear to have orbital characteristics analogous to American explosion-detection satellites.

(3) <u>Seismic monitoring</u> (pp.38-43):

Seismic monitoring methods can detect and identify underground nuclear explosions. Earthquakes can be distinguished from explosions by the type of sesmic waves they produce. Explosions generate mostly P-waves (primary waves) because the pressure on the walls of the cavity is uniform. Earthquakes, however, produce mainly S-waves (secondary-waves or shear waves) and the pattern of seismic wave propagation is asymmetric. Depth can also aid identification because 90 percent of the world's earthquakes occur at depths of 30 km or more. Current drilling capabilities relevant to the placement of explosives extend only to about 10 km. After eliminating many events with the criteria of wave type, depth and location, further discrimination is possible by examining the ratio of the strengths of body wave (m_b) to surface wave (M_s). An explosion would generate smaller Rayleigh and Love waves than an earthquake of corresponding magnitude. Wave characteristics can permit estimates of explosive yields also, but accurate estimates are difficult to make when explosions are in the range of a few kilotons.

Table 8 (p.121) summarizes the capabilities of a network of fifty seismic stations distributed throughout the world. A regional seismic test network has been proposed and investigated in the United States (see abstract K56(A83)). Stations 2,000 km apart have been placed at five sites in North America. They transmit data via satellite to a system control and receiving station. These stations are intended to replicate the system which might be installed in the USSR under a comprehensive test ban treaty so they are operating in geological conditions similar to those which might be encountered in the USSR.

Distinguishing between earthquakes and explosions is possible with a high degree of certainty for events of body wave magnitude greater than 4.5. This figure corresponds to 3-5 kt of explosive yield in hard rocks and higher yields in dry alluvium. Geological factors can cause variations in these figures. Figure 10 (p.130) illustrates the relationship between seismic body wave (m_b) and explosive yield which has been determined for different geological

environments. A well-coupled 1 kt explosion in hard rock will generate a seismic signal of magnitude 3.8 in the US. The same explosion in the USSR would produce a yield of magnitude 4.2. Estimates suggest that an array of fifteen high-quality in-country seismic stations could detect explosions with a 90 percent confidence level for yields as low as 3 kt or 10 kt with decoupled explosions. If thirty stations were used, the detectable yield could be as low as 1 kt.

(4) Non-seismic detection (pp. 43-45):

Non-seismic methods for detecting a nuclear explosion on the surface of the earth or underground include gound-based radar techniques for monitoring ionospheric disturbances caused by shock waves. While this technique appears possible, it has not been developed sufficiently to be practical over long-ranges or to determine explosive yield. Satellite monitoring of ionospheric disturbances is also being investigated. Various satellites have been launched for this purpose, the most recent being two ionospheric sounding satellites ISS-1 and-2 launched by Japan in 1976 and 1978 respectively. Very low frequency (VLF) receivers on satellites can observe movements of electrons caused by acoustic waves from an underground explosion. With regard to verification of a comprehensive test ban treaty, the authors assert that "with a complete ban on tests, the above [seismic and non-seismic detection] methods should surely be sufficient, since under a CTBT it would only be necessary to conduct a nuclear explosion to violate the treaty" (p.45).

(5) An international or regional satellite monitoring agency (pp. 45-50):

In considering the possibilities of establishing an International or Regional Satellite Monitoring Agency (ISMA or RSMA), the authors suggest that obstacles to an ISMA urge further consideration of establishing an RSMA. Impediments to creating an ISMA consist of superpower reluctance to give up their monopoly on space technology and concern about the modalities of data acquisition and dissemination. Europe could be the first region for an RSMA. A regional infrastructure, the European Space Agency (ESA) and the Interkosmos Council in Eastern Europe, already exists. Both organizations have active space programmes in the field of remote sensing which could be useful for the verification of arms control agreements. The organizations are also linked because France has orbited scientific experiments on Soviet Cosmos satellites and French astronauts have flown on Salyut-Soyuz spacecraft.

Cloud cover over Europe need not pose an obstacle to verification because civilian satellites fitted with synthetic aperture radar (SAR) would have all-weather day and night capabilities. SAR has a resolution capability of 25 m, but depends on a high data-rate telemetry link and extensive ground-based data processing facilities. These processing facilities are already in place in the Federal Republic of Germany and various sensors which might be useful for an RSMA are being developed there also. A German optical sensor using charged-couple devices producing a ground resolution of 20 m was orbited on the US space shuttle Columbia on 28 November 1983.

The authors suggest that an RSMA may not be confronted by the same obstacles as an ISMA. Access to sensitive data will probably not be a cause for concern since astronauts from the West have already orbited aboard Eastern Bloc spacecrafts. It also appears that the US, and probably the USSR, have begun to share with allies data obtained from military photographic reconnaissance satellites (p.49). A body similar to the Standing Consultative Commission established by SALT negotiations could promote the provisions of any arms control agreement for Europe and could also help to reduce the dangers of a surprise attack. There are many precedents for international cooperation in satellite observation programmes. Examples of joint projects include INTELSAT and INMARSAT (communications and navigation), METEOSAT (meteorology) and COPSAS/SARSAT (a "search and rescue" programme).

The book includes a number of appendices and tables which list the verification provisions of existing arms control agreements, international organizations relevant to arms control treaties and the characteristics and capabilities of various satellites and sensors.

Proposal Abstract J30(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar

   (b) On-site inspection - selective

3. **Source:**
   Krepon, Michael. "Verifying Arms Control Treaties". In Nuclear War: The Search for Solutions, pp. 187-192. Proceedings of a Conference held at the University of British Columbia 19-21 October, 1984. Manitoba: Friesen Printers, 1985.

4. **Summary:**

The central premise of this article is that verification will always be complicated by the tendency of the superpowers to seek an advantage in arms control, while the essence of agreement is an equilibrium; "the hard part is to regulate this sort of competition" (p. 188). Various verification measures are considered briefly - photoreconnaissance with high resolution and clarity, heat detecting devices which can provide continuous round-the-clock monitoring capabilities, radar which is capable of monitoring various stages in Soviet missile tests, and satellites and other means which can intercept enemy military communications.

Despite improvements in monitoring capabilities, however, uncertainty about compliance with an arms control treaty will remain. More information will not necessarily be less ambiguous, may confuse rather than clarify the issue, and will still be evaluated subjectively. Developments in monitoring capabilities will be matched, and in some cases surpassed by concomitant improvements in weapons mobility, concealability and deployment modes. Consequently, other forms of verification must be employed which will supplement national technical means of surveillance. On-site verification in itself will not be a panacea since it can only monitor specific locations at certain times. It is concluded that future success in arms control will "rely more on things like cooperative measures and counting rules" (p. 189). "Questions of compliance are going to arise in arms control because no agreement can cover every single eventuality" (p. 192). Furthermore, the parties to an agreement will attempt to exploit any ambiguities and may go so far as to formulate vague agreements which leave a wide margin for error.

Proposal Abstract J31(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   Ranger, Robin. The Arms Control and Crisis Management Potential of the Proposed International Satellite Monitoring Agency (ISMA). Ottawa: Operational Research and Analysis Establishment, Department of National Defence, December 1984. Extra-mural paper no. 34.

4. **Summary:**

In evaluating the potential contribution of an International Satellite Monitoring Agency (ISMA), Ranger argues that literature in the public domain has been deficient in the area of assessing the capability of an ISMA to perform arms control and crisis management functions. Based on his own research, Ranger concludes that an ISMA would have difficulties making the contribution to arms control verification that its many proponents envisage.

It appears unlikely that an ISMA could be organized and financed in such a way to provide "the requisite technical verification capabilities" (p. 11). An ISMA would have limited information gathering capabilities and would not have access to the classified information necessary to demonstrate non-compliance with an arms control agreement. Even if it could overcome the problems of technical interpretation, an ISMA would still have to face the problem of political and legal judgment necessary to demonstrate non-compliance. An ISMA would be incapable of dealing with a situation in which the potential violating state rejected the evidence of violations. Furthermore, Ranger concludes that "it is...difficult to see what additional useful contribution an ISMA could make to crisis management, given its technical and political limitations" (p.113) since the Americans have already begun to use command, control, communications and intelligence (C^3I) systems to inform allies of potential crises.

Proposal Abstract J31.1(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar

   (b) International control organization - ISMA

3. **Source:**
   Cantafio, Leopold J. "Space-Based Radar for the United Nations' International Satellite Monitoring Agency". Microwave Journal 27 (December 1984): pp. 115-121.

4. **Summary:**
   This article briefly reviews the history of the ISMA concept and describes the technical mission and data requirements of the satellite system. it then proposes a space-based synthetic aperture radar configuration that would provide the required data. Critical technologies and tradeoffs are discussed. A resolution of 10 cm is suggested as possible. Each satellite is estimated to have a ten-year life cycle cost of $12.24 million excluding costs of electro-optical sensors and launch. It would take four to five years to construct such a satellite including the R & D phase.

Proposal Abstract J32(A84)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Richelson, Jeffrey. "The Keyhole Satellite Program". Journal of Strategic Studies 7, no. 2 (June 1984): 121-153.

4. **Summary:**

The development of the US Keyhole Satellite Program (KH satellites) is described on the basis of somewhat limited available information. The author's approach is a multi-dimensional one, beginning with the known capabilities of the sensors used in reconnaissance satellites, followed by a review of the historical development of the program and an in-depth explanation of the satellites currently in use.

Sensors and Enhancement Techniques:

Photography is the central means of obtaining imagery from satellites, and may be supplemented by other means which produce images using different electromagnetic impulses. Photographs use the "visible light" end of the electromagnetic sprectrum, and may be either film-based or "electro-optical", meaning that images are created by translating light levels into electrical signals. Infrared photography records reflection from objects and uses "false colour" which changes the natural colour of objects in order to detect camouflaged vehicles or weapons. Thermal infra-red scanners may also be used to locate or identify objects according to the heat they emit, and are thus able to detect buried structures and monitor night-time activity. Finally, radar can be used to produce imaging by bouncing waves off an area or object. This method has the added advantage of being able to penetrate cloud cover.

Satellite imagery may be enhanced by a number of techniques which improve the coverage and quality of various sensors. Multispectral scanners take a series of pictures through separate lenses with different visible light and infra-red frequencies to provide a more complete picture. "Image enhancement" may also be used, a process whereby computers translate the picture into mathematical formulae "to manipulate the colour contrast and intensity of each spot" (p. 123). This method seeks to alter the contrast, angle and focus of an image in order to better distinguish certain objects. A third enhancement technique, known as optical subtraction, seeks to remove insignificant objects from an image so that a particular site or object may be more easily discerned.

Historical Background:

The Keyhole satellite program grew out of two projects for satellite research and development known as the SAMOS and CORONA projects. The first launch to be formally dubbed as a KH satellite took place on March 7, 1962, and was part of the Discoverer/CORONA program. Subsequently, all launches took place under the aegis of the Keyhole program and existing satellites were retroactively dubbed as first generation KH satellites. The organizational structure of the KH program gradually evolved through 1958-1962, and in 1961 the Air Force took total control of satellite reconnaissance programs. A National Reconnaissance Office was established as a central managing office. From the beginning, the official position on the requisite level of secrecy in this program was unclear. The State Department was keen to establish the legitimacy of the program, while military and high government officials preferred the cloak of secrecy. Ultimately, the government position stressed the civilian uses and benefits of observation satellites, while their military functions were simultaneously downplayed.

Keyhole Satellites:

Each of the earlier KH satellites is carefully considered individually, both as a phase in the evolution of KH satellites in general, and in terms of each satellite's developmental stages. Major improvements have been made to the KH series of satellites; they now have longer lifetimes, more flexible and varied orbits, with improved data transmission, read-out speed, resolution, and coverage time (p. 140). The KH-11 actually has an instantaneous read-out time which may provide a significant advantage in war-time situations. Satellites now provide vastly extended coverage, as each may orbit for longer periods over specific areas.

It is asserted that the impact of satellites on defence policy has been significant. They have provided a much wider data base for decision-making and may also be especially useful in monitoring crises. Finally, strategic weapons may be accurately targeted at Soviet territory, since satellites can accurately locate and identify Soviet military installations.

Some limitations on the effectiveness of satellites persist, however. Both cloud cover and darkness impede reconnaissance, and although infra-red sensors can operate at night, their resolution is poor. Cloud cover is a serious problem in view of the fact that some areas in the Soviet Union are under cloud cover for most of the year. Finally, the predictability of the satellite's passage over a given area may provide the Soviets with opportunities for deception or concealment of activities.

The article continues with a discussion of the present status of the KH series. The most important feature of KH-12 is the presence of thermal imagery sensors for night-time surveillance. There are also plans for a satellite equipped with imaging radar. The author also discusses changes to the satellite reconnaissance management apparatus. US policies on public disclosure of satellite photographs are reviewed and the author concludes that they should be more openly available.

J33(A85)

Proposal Abstract J33(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellites
   (b) International control organization - United Nations
   - ISMA
   (c) On-site inspection - general

3. **Source:**
   Arbess, Daniel and William Epstein. "Disarmament Role for the United Nations?" Bulletin of the Atomic Scientists 41, no. 5 (May 1985): 26-28.

4. **Summary:**
The authors note the failure of efforts to negotiate arms control and disarmament and cite, in particular, American opposition to a CTB despite widespread international support for such a treaty. The article proposes a number of ways in which the United Nations could facilitate disarmament. The United Nations could establish an International Satellite Monitoring Agency (ISMA) to help verify arms control treaties; to deter arms testing, deployments and transfers; and to supply information for crisis management and peacekeeping operations. Multilateral observation teams could monitor cruise missile deployments as well as troop movements and numbers for an MBFR agreement. More effective international peacekeeping forces could help in securing compliance with arms control and arms transfer agreements. The authors propose that these forces should differ from past UN peacekeeping forces in two ways: they should be permanent and should be composed of soldiers recruited individually rather than by national contingent.

Proposal Abstract J34(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite
   - radar
   - aerial

3. **Source:**
   Hafemeister, David. "Advances in Verification Technology". Bulletin of the Atomic Scientists 41, no. 1 (January 1985): 35-40.

4. **Summary:**

Recent advances in verification technology are enumerated in this paper, and it is noted that these developments may significantly enhance the United States' ability to verify compliance with arms control treaties. High quality technical means of verification are important insofar as they inspire a more cautious attitude, tend to stabilize the arms race, provide timely warning of any significant breakout, and are a prerequisite for the ratification of any arms control treaty.

Although cheating may be technically possible where an agreement is adequately verified, "the technical means of verification need not be totally reliable in order to deter a nation from cheating" (p.35). Some of the most dramatic advances have been made in the field of satellite photography, as ground resolution becomes increasingly refined. It is estimated that "recent improvements in optics and film quality facilitate ground resolution of anywhere between five and twelve centimetres from a relatively low orbit" (p.37). The verification process may seek to monitor either objects or activities. Objects may be monitored by reconnaissance satellites, radar and human intelligence. These sources provide data on size and shape to determine identity. Sample photographs show how sufficiently high resolution will allow identification of an object even where details seem indistinguishable. To monitor activities, a detector must be "time sensitive", meaning that the activity must be observable at all stages in order to be measured. This continuous monitoring is possible with the combined use of "radar and optical systems located on land, sea and air" (p.36).

Photography is now further enhanced by digital image processing which provides greater detail and higher resolution. Here, the image of a highway under cloud cover demonstrates the effects of digital image processing. Shapes are revealed as the contrast in the photograph is enhanced by electronic devices which translate areas of light and dark into numbers. This digital image processing also

restores those edges and lines which are blurred by photography in the transition from dark to light. Finally, photographs are clarified by the process as it removes extraneous detail, leaving only the large objects to be analysed.

The film used in satellites may be transmitted via television cameras and fibre-optics readers, or it may be physically returned to the earth for analysis in a film canister. The latter method tends to be slow, but the high quality resolution of the film is preserved. Even so, film returned to earth still has a narrow range of contrast from white to black, a low quantum efficiency and is non-linear. The development of charge coupled devices has solved many of these problems, however. These are semi-conducting devices that translate light into a charge which can then be measured to produce an image. They can thus replace film and allow the image to be read directly into a computer so that information is relayed immediately. They are more reliable than film, are small and require little energy, and thus are much more sensitive to infra-red and a wider range of white and black.

Proposal Abstract J35(A85)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Nuclear weapons - comprehensive test ban
   - ballistic missiles
   - missile tests
   - reentry vehicles

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar
   - ELINT
   (b) Seismic sensors - intra-border stations

3. **Source:**
   Hafemeister, David, Joseph J. Romm, and Kosta Tsipis. "The Verification of Compliance with Arms Control Agreements". Scientific American 252, no. 3 (March 1985): 39-45.

4. **Summary:**

The actual capabilities of US monitoring and reconnaissance technologies are explored in an attempt to discern whether they could adequately verify an arms control treaty. Two separate questions are addressed. "First, at what level of clandestine Soviet activity would US security be jeopardized? Second, is the US system of verification capable of detecting that activity?" (p.34).

Four levels of activity are identified at which weapons may be monitored - research and development, testing, production and deployment. It may be easier to detect deployment insofar as it is carried out over a period of years, whereas testing and production are singular occurences which must be detected within a certain time period. While any one stage may be difficult to detect, it may still be possible to determine the purpose or object of an activity; even the slightest clue might reveal a violation. Finally, there is a 'natural synergy' between various information gathering sources, since the information provided by one may suggest where another should look and what to look for. It is acknowledged, nevertheless, that there remains "a measure of ambiguity and uncertainty inherent in this task" (p.40).

Three means of verification which comprise national technical means are described in terms of their function and capability. These are the monitoring of light images, electromagnetic waves and acoustic waves. The first of these techniques utilizes photoreconnaissance satellites. The cameras used on these satellites may have a resolution of 10 centimetres and can distinguish objects as small as

1.5 metres across. Diagrams and photographs are included which demonstrate how cameras with a larger focal length are able to produce better resolution. Even where resolution is not perfect, activities and objects may be distinguished through analysis. One must know what to look for and piece together information gathered from all monitoring systems. Where resolution is poor, an object may be only detected and not identified; if resolution improves, that same object may then be recognized. Images may be recorded on film and later returned to earth or transmitted via electro-optical detectors in 'real time'. These satellite sensors are limited to some extent, however, by the fact that they cannot operate at night or penetrate cloud cover.

The second national technical means of verification is that which employs radar. These sensors are not impeded by darkness or cloud cover, but have significantly lower resolution as compared to photoreconnaissance. Land-based radars are extremely useful for monitoring missile tests, and may provide precise information on the missile's speed and accuracy. "Radar can measure continuously and with great precision the velocity of the missile and hence its acceleration..." (p.42). Their capability has also recently been extended with the development of 'over the horizon' radars.

Radio receivers may be used to intercept telemetry (messages sent during missile tests which provide information on the missile's components and performance). Such interceptions are a source of important information on the characteristics of the missile being tested, although some uncertainty will remain regarding accuracy, reliability and potential yield of the missile. Telemetry may, however, be encrypted, although this has been restricted under the SALT II Treaty. Finally, phased array radars monitor the return of Soviet reentry vehicles, while "infra-red and visible light telescopes equipped with cameras and rapid scan spectrometers record in great detail the various forms of radiant energy emitted and reflected by the reentry vehicle" (p.43).

The third means of verification discussed is the use of seismometers to detect underground tests through the acoustic waves that they produce. Previously, such testing was often difficult to distinguish from natural phenomena such as earthquakes. Moreover, the possibility exists that earthquakes could be used to effectively mask a nuclear explosion where they were timed to occur simultaneously. Seismologists can now distinguish between the two, however, since the earthquake generates longer waves as a widespread event, while the nuclear explosion occurs at a specific point. "As a result, the waves from a nuclear explosion can be detected and recognized by their frequency characteristics even if they are accompanied by those of an earthquake" (p.44). Even smaller explosions of under one kiloton which might be muffled can now be detected through the use of remote sensors at seismic stations on Soviet territory. The political acceptability of such on-site seismic stations will be enhanced by the development of unmanned seismic stations.

It is concluded that certain kinds of treaties are verifiable in view of the current capabilities of US national technical means of verification. A comprehensive test ban could be verified well enough to maintain national security, and a similar ban on ballistic missile testing would be verified with a 90% chance of detection of violations. Finally, it is noted that detection need not be perfect, since large scale activities of any significance are easily observed, and a high level of confidence is possible when there is a complete ban which is easier to verify.

 J36(A85)

Proposal Abstract J36(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Rekenthaler, Douglas A. "Satellite Surveillance: New Policy Issues?" Journal of Defense and Diplomacy (September 1985): 15-19.

4. **Summary:**

The article describes current and future developments regarding both commercial and military remote sensing from satellites. This abstract focusses on the discussion of military systems.

The author identifies several trends likely to change the historical predominance of the superpowers in the field of satellite remote sensing, including: a dramatic increase in the number of national participants in the field, the cost of remote sensors is now within reach of many states and high-performance sensors are readily available.

All remote sensor systems require compromises over the ideal, based on available technology. Military remote sensor users prefer panchromatic (black and white) products, with high resolution as opposed to civilian users who demand multispectral imagery with moderate resolution. There is an erroneous tendency on the part of laymen to attribute very fine resolution, worldwide coverage, real-time responsiveness, and other excessive capabilities to military sensors.

Military users seek to employ satellite sensors to detect, classify (types of threats), identify (specific units), position and track objects. They are, however, frequently frustrated by the inherent limitations of satellite reconnaissance. Very high resolution remote sensing requires not only collection, but also transmission, storage and processing of immense amounts of data. These problems are compounded when synthetic aperture radar is employed. Present capabilities of artificial intelligence and computerized pattern recognition are limited, requiring the support of large numbers of trained and experienced human photo-interpreters.

Massive amounts of data are required, not only because of the high resolution demanded, but also by the desire for frequent coverage of the target area and the large number of targets. The need for near real-time feedback to users adds an additional demand on the system. In the future, collection technology may fall in priority as the importance of processing and exploiting data for the user rises.

Survivability of satellite assets in tomorrow's war environment questions the wisdom of so much emphasis on a single collection technique (i.e. satellites). This leads to arguments for renewed interest in other intelligence gathering techniques such as signals intelligence (SIGINT) and human intelligence (HUMINT). Such additional techniques will be expensive and require up to 10 years lead time to establish.

The Soviet emphasis on camouflage, concealment, denial and deception underscores the need for corroborative evidence from terrestrial intelligence sources.

Proposal Abstract J37(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Seismic sensors

3. **Source:**
   Schear, James. "Cooperative Measures of Verification: How Necessary? How Effective?" In Verification and Arms Control, pp. 7-35. Edited by William C. Potter. Lexington, Mass.: D.C. Heath and Co., 1985.

4. **Summary:**
   "Cooperative verification" involves the use of voluntary or negotiated measures to improve the verifiability of arms control agreements. It can be implemented in many different ways which range from agreeing to negotiating limitations that can be verified with unilateral monitoring methods (SALT) to reciprocal on-site inspection. The recent approach taken by the Reagan Administration has manifested a desire to obtain cooperative measures for verification which go further than national technical means (NTM). This article discusses the Soviet and American positions on cooperative measures and the rationale behind those positions. The utility of various cooperative measures is considered in detail.

   Schear concludes that cooperative measures by themselves have limited effectiveness as a verification method, but that they can enhance the capabilities of NTM. There are a number of problems associated with negotiating active cooperative measures, particularly on-site inspection. The first is political in nature: a balanced compromise is difficult to arrive at, often because Soviet officials are reluctant to concede to the United States on verification and Western officials object to the use of verification as a bargaining chip offered in return for other concessions. Second, neither side will want to agree to implement measures which may reveal sensitive intelligence information. Third, legal and political obstacles may arise such as challenges over the constitutionality of on-site inspection. Last, cooperative measures may not necessarily improve verifiability in any case. For example, an exchange of information is useless if one side can't authenticate the data provided by the other side. Authentication problems may also arise in connection with on-site inspections.

   On the other hand, passive cooperative measures which seek to enhance the capabilities of NTMs(rather than to obtain information which cannot be gathered by NTMs, a task of active cooperative

measures) can be of some use. NTMs could detect, count and measure qualitative changes in the performance of weapons more effectively if measures were taken to incorporate transparency into the production and basing of weapons and to designate areas where they can be produced or deployed. Other passive measures include "collateral constraints" to prevent possible methods of evasion and to stop legal activities from threatening the intent of a treaty. Clarifying thresholds of acceptable behaviour and establishing "counting rules" (as in SALT II) can also improve the effectiveness of the verification regime.

The article discusses the various methods of cooperative verification in detail, making references to Soviet-American arms control negotiations. Passive measures covered include: (a) designation measures which localize the weapons systems which NTMsneed to count or assess in qualitative terms; (b) transparency measures to increase the visibility of weapons testing, production and deployment; (c) collateral measures to prevent evasion; and (d) clarifications and counting aids. Table 2-1 (p.17) displays various designation measures, their precedents and implications. Table 2-2 (pp. 19-20) makes a similar display of transparency measures.

A section on active cooperative measures focuses on the role and limits of on-site inspection. "First-order" inspection measures are designed to enhance NTMsby obtaining data on permitted activities which transparency measures cannot provide. This could include monitoring the movement of systems between final-assembly plants and designated deployment areas. It could also include supervision of the closing down of a production facility or the destruction of weapons. "Second order" inspections are conducted in connection with NTM-detected signals which indicate the covert production and deployment of restricted systems. Schear concludes that "once it is clear that inspections could never be an open-ended invitation to the other side's intelligence personnel, second-order OSI [on-site inspection] begins to lose its attractiveness, even as a deterrent." (p.29). The case of nuclear weapons testing, as it concerns on-site inspection, is unique because seismic detection methods can establish evidence in advance and localize the area of concern which would be inspected. Incriminating evidence such as aftershocks may be difficult to conceal. These favorable conditions are not present in other areas of arms control.

Proposal Abstract J38(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) On-site inspection - selective

3. **Source:**
   Scott, William F. "Asymmetries in Arms Control Verification". Armed Forces Journal International (February 1985): 94-96.

4. **Summary:**
   The article asserts that there is a serious asymmetry between the Soviet Union and the United States in terms of access to the adversary's territory. This proposition is supported by a comparison of the freedom of movement in these countries. Restrictions in travel and the closed nature of Soviet society may allow the regulation of the flow of information and the creation of a carefully constructed image of Soviet society. This potential for secrecy is compounded by the fact that data provided by US satellites is simply inadequate. It is concluded that the asymmetry between US monitoring capabilities and Soviet access to US information is too great to be offset by any form of agreement.

Proposal Abstract J39(A85)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Nuclear weapons - ballistic missiles
   - manned aircraft
   - missile tests
   - partial test ban

2. **Verification Type:**
   Remote sensors - satellite
   - aerial
   - ground-based
   - ELINT
   - radar

3. **Source:**
   "Specialist Describes US ReCon Sats". Military Space (April 1, 1985): 1,4,5.

4. **Summary:**

This article summarizes a paper presented by Jeffrey Richelson of the American University in Washington at a recent International Studies Association conference in Washington. The surveillance satellites and sensor technology which comprise the US national technical means of verification are described in detail. It is based on a collection of unclassified data which give a good idea of US technical capabilities. Five categories are distinguished within the parameters of national technical means of verification: photoreconnaissance or imaging, signals intelligence, ocean surveillance, space surveillance and nuclear monitoring. In each of these categories, monitors are used in different modes (space, airborne, seaborne and ground-based sensor operations).

Sensor technology is designated for various monitoring, surveillance and verification functions. Some of the current verification tasks include the detection of multiple warheads on intercontinental or submarine launched ballistic missiles, "structural modifications for SALT accountable bombers", and detailed assessments of ground sites. Surveillance satellites must provide better resolution, additional ocean surveillance and space-based nuclear detection.

Photoreconnaissance or Imaging Satellites

Much detailed information is provided on US surveillance satellites:

(1) The KH-8: This is the oldest US imaging satellite, and is a third-generation 'close look' satellite which has the greatest resolution. It can perform 80 day missions with an orbit of 215/77 miles.

(2) The KH-9 'Big Bird': This satellite weighs about 30,000 pounds, is 50 feet long and 10 feet wide, and may carry four returnable film capsules. It is launched into a "sun-synchronous polar orbit with apogee/perigee of 155/100 miles, and repeats its ground track every 3.5 days" (p.4).

(3) The KH-11: This is a first generation real-time digital imaging satellite which transmits its images to two locations using either the Satellite Data System or the Tracking and Data Relay Satellite (TDRSS). It has the longest lifetime of any satellite, with flights of 770 days in duration.

(4) The KH-12: This satellite currently in development will have resolution similar to that of the KH-8, and is scheduled for launch in 1986. Plans for a super-KH satellite were cancelled after the realization of the enormous processing load its sensors would generate. An imaging radar satellite is also being planned.

SIGINT Satellites in Strategic, Tactical and Naval Roles

Signals intelligence, or SIGINT, uses two kinds of satellites; the first is in a geosynchronous orbit, "and can be targeted against telemetry, C^3, radar and telephonic emitters across VHF, UHF and microwave frequencies" (p.4). Both the Rhyolite and Chalet satellites fall into this category as geosynchronous satellites. The second class of satellites include ferret SIGINTs which are used in lower orbits to 'map' Soviet and Chinese radars. Their orbits are distinctively higher than KH-class orbits, but lower than all other US military satellites. The ferrets include a "piggyback" class that are launched with larger satellites, then ejected into individual orbits" (p.4).

Various functions fall under the heading of signals intelligence. "Richelson includes in this category RADINT (radar intelligence) for sensing both imaging and non-imaging radars; TELINT (telemetry intelligence), particularly important for assessing SALT-related performance parameters; FISINT (foreign instrumentation signals intelligence) including telemetry, beaconing, electronic interrogators, video data links, and tracking, fusing, aiming and command systems; and two other areas listed under a proposed 1986 NSA charter: "non-imaging infra-red (IR), involving remote sensing, and coherent light signals, apparently a reference to laser communications..." (p.4).

Ocean Surveillance

Another area which is described by Richelson is that of Navy activities in ocean surveillance. A program for a dedicated overhead system for ocean surveillance was developed in 1976. "This Program 749 study focussed on high-resolution phased array radar satellites for all-weather ocean coverage and detection of low-trajectory sea-launched missiles. IR scanners were also suggested for such satellites" (p.4). The 'Classic Wizard' Ocean Surveillance System was subsequently developed, but it lacks radar capability. Instead, the system has passive IR scanners, millimeter wave radiometers, antennas for monitoring transmissions, a 'mother' satellite and three

sub-satellies operating in 'near' circular 700-mile orbits. Five satellite clusters are purported to be currently in operation, and the cluster apparently uses passive interferometry techniques to determine vessel locations with overlapping coverage on successive passes" (p.5). Finally, U-2 aircraft provide additional ocean surveillance using high-resolution radar, IR scanners and ELINT and COMINT ocean surveillance receivers.

Space Nuclear Detection and Other Functions

The KH-11 may currently be providing some form of space-based space surveillance, as indicated by "1981 press accounts of the KH-11 being used during the first shuttle flight to verify the condition of the tiles on the shuttle's fuselage" (p.5). Some other programs for space surveillance includes DARPA's SIRE (Space Infra-red Experiments) program and the USF's Space-Based Surveillance System (SBSS) which uses 4 low-orbit satellites equipped with long-wave IR sensors. Lastly, the NUDET detection system for nuclear detonation detection used aboard Global Positioning satellites now provide space-based nuclear detection, replacing the 'recently deactivated' VELA class of satellites.

Proposal Abstract J40(A85)

1. **Arms Control Problem:**
   Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   "Time to Go Into Space". <u>New Scientist</u> 105, no. 1440 (24 January, 1985): 16.

4. **Summary:**
   NASA's plans to build a permament space station may provide an avenue for greater European involvement in the exploration of space. European participation and international involvement in general would help to shape the project, and would allow a truly international research effort in space wherein Europe might maintain a degree of influence. The venture will be costly, however, and some objections have been raised about the political implications of closer ties with US military initiatives. Such a station might prove to be a useful verification tool; it could operate as an international reconnaissance satellite to be used for the verification of arms control treaties. As such, it is remotely possible that a station would be an "orbiting bridge between East and West" (p. 16).

Proposal Abstract J41(G85)

1. **Arms Control Problem:**
   (a) Any arms control agreement
   (b) Nuclear weapons - ballistic missiles
   (c) Chemical and biological weapons - use

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   United States. Congress. House of Representatives. Committee on Armed Services. Procurement and Military Nuclear Systems Subcommittee. Special Panel on Arms Control and Disarmament. Review of Arms Control and Disarmament Activities: 98th Congress. Washington: US Government Printing Office, 1985 (pp. 17-22).

4. **Summary:**

One section in this report is devoted to the importance of adequate verification and the gravity of non-compliance with an arms control treaty. Evidence of violations seems to indicate that national technical means of verification (NTM) are no longer sufficient to monitor increasingly technical and diverse weapons systems. This situation is untenable since adequate verification is an indispensable part of arms control which provides timely warning of any threat to national security. Therefore, no arms control agreement should restrict any activity which cannot be adequately and promptly verified. Every agreement will pose unique verification problems which are generally exacerbated by the closed nature of Soviet society and attempts at concealment and deception.

Some additional complications are foreseen in the near future as recent arms control agreements now attempt to reduce the number of warheads. This is necessary given the interchangeability or flexibility of new weapons and launchers. In almost every instance, verification requirements will exceed the capabilities of NTMs, and "would require various mandatory inspection and other cooperative measures" (p.19). Given these increased demands and potential obstacles to verification, it may be necessary to resolve general verification issues prior to detailed arms control negotiations.

Specific problems are envisaged in the verification of chemical, biological and toxic weapons treaties, since the existing agreements do not make any provision for verification or enforcement. They rely on the force of world opinion to deter violations, but the current unilateral verification capabilities are not sufficient to provide concrete evidence which might prompt an international response.

Further, Soviet use and production of chemical weapons is unlikely to be deterred by the threat of retaliation, since few nations have the ability to respond in kind. It is thus concluded that Soviet violations of chemical and biological weapons treaties will seriously undermine the whole arms control endeavour.

Proposal Abstract J42(G57)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) Remote sensors - aerial
   (b) On-site inspection - control posts

3. **Source:**
   United States. White House Disarmament Staff. Fact Sheet on Aerial Inspection. Washington, D.C.: September 1957 Disarmament Background Series, No. 1-9. Cited in Inspection for Disarmament, pp. 69-71. Edited by Seymour Melman. New York: Columbia University Press, 1958.

4. **Summary:**
   The authors suggest the following:
   (1) Specially designed peripheral air bases just within the boundaries of participating nations could be used as clearance points for inspection flights. Air inspection command posts might be permanently stationed at such bases.
   (2) Preparatory to every aerial inspection missions, aircraft could be closely examined by representatives of the host country either visually and/or by radiation detection devices.
   (3) A representative of either the host country or the international control organization would be assigned to each inspection mission to ensure compliance with all regulations. He might be allowed to maintain radio communication with the monitoring agency of the inspected country.
   (4) Air inspection teams, while being unrestricted as to where they might fly (provided this area fell within the terms of the arms control agreement), would be required to file a detailed flight plan in advance of the inspection mission and would be obliged to adhere strictly to the plan.
   (5) All inspection aircraft would be unarmed and crews would be required to adhere closely to regulations governing air traffic safety in the host country.
   (6) Throughout their inspection flight, aircraft would be kept under constant surveillance, either electronically or visually by an armed host country companion plane.
   (7) The same provisions as in #4 and #6 could be used to control the approach of inspection planes to national frontiers. These could be required to follow designated air corridors.
   (8) Following inspection flights, the host country would have no access to reconnaissance material gathered during the mission. Unless the agreement provided for international control of the information, it would remain the sole property of the nation which had conducted the inspection mission.

J43(A68)

Proposal Abstract J43(A68)

1. **Arms Control Problem:**
   General and complete disarmament

2. **Verification Type:**
   (a) Remote sensors - aerial
   (b) On-site inspection - progressive/zonal

3. **Source:**
   Frye, W.R. "The Disarmament Turning Point". Bulletin of the Atomic Scientists 12, no. 5 (May 1968): 166-168.

4. **Summary:**
   This proposal envisages initial projects of aerial and ground inspection to act as confidence-building measures in a process of progressive verification. Initially, relatively small areas (perhaps 20,000 - 30,000 square miles) could be made subject to aerial surveillance, with ground personnel inspecting at least one communications centre and one airfield in each area. Aerial and ground inspectors would report directly to a central control headquarters.

   If all goes well, the area open to inspection could be gradually enlarged, until all territory was opened to general inspection.

Proposal Abstract J44(A75)

1. **Arms Control Problem:**
   (a) Regional arms control - demilitarization
   - Mediterranean Sea
   - Indian Ocean

   (b) Conventional weapons - ships

2. **Verification Type:**
   (a) Remote sensors - satellite
   - aerial

   (b) Complaints procedure - consultative commission

3. **Source:**
   Blechman, B.M. <u>The Control of Naval Armaments: Prospects and Possibilities</u>. Washington, D.C.: The Brookings Institute, 1975. Especially pp. 42-46 and Appendix B.

4. **Summary:**

The author proposes a format for agreements between the two superpowers on regional naval disengagement. His focus is mainly on two geographic areas: the Mediterranean Sea and the Indian Ocean. The proposed agreement would provide for removal of naval forces and perhaps shore installations from the area in question, as well as restrictions on future naval deployment there. As envisaged, each party would rely primarily on "unilateral means of verification" by which is meant satellite and aerial reconnaissance. In respect to an agreement on disengagement in the Mediterranean, Blechman foresees little difficulty concerning such monitoring techniques. The Mediterranean is surrounded by land areas with only a few narrow entrance and exit points at which movements of naval vessels including submarines could easily be monitored.

The problem is somewhat more difficult in regard to disengagement in the Indian Ocean, which unlike the Mediterranean is an open body of water. Nevertheless, Blechman believes that satellite reconnaissance would be sufficient to detect any violation by surface ships in the area. Submarines pose a more serious problem since they can not be detected from satellites. "It might be possible to monitor a submarine restriction by tracking all submarines from the time they left their home ports, but neither signatory would have much confidence in such an approach" (p. 70). To counter-balance this problem over verification the author points out the serious political consequences that would be entailed by any breach. Furthermore, the author can not imagine how any Soviet infringement "even if large numbers of submarines were involved (which, of course, increases the likelihood of discovery), could seriously jeopardize the security interests of the United States". These considerations suggest that the verification problem with respect to submarines should be overlooked.

In addition to national means of verification, Blechman proposes the establishment of a "joint control commission", to oversee implementation of the agreement. The membership of the Commission would consists of one representative from each superpower and one delegate nominated by the littoral states of the region in question. The commission's functions would be:

> ... to report on activities and to serve as a forum for continual consultation and negotiation. Nations deploying forces in the region would inform the commission in advance, which would then monitor and report their compliance with or deviation from prescribed limitations. Involving local states in verification of the agreement is an additional insurance against cheating or other forms of non-cooperation. Under a commission so constituted, a violation would be not only against the other signatory but against the states of the region. (p. 46).

Proposal Abstract J45(A76)

1. **Arms Control Problem:**
   Regional arms control - Europe

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - control posts

3. **Source:**
   Lodal, Jan M. "Verifying SALT". Foreign Affairs 24 (Fall 1976): 62-64.

4. **Summary:**
   Little attention has been paid to verification problems in the context of mutual and balanced force reductions in Europe according to Lodal. Relatively modest troop reductions (20,000 to 50,000 troops) such as those most commonly discussed for an MBFR first step, cannot be verified with high confidence by national technical means. Distinguishing troop withdrawals from rotation of troops would be difficult without a massive inspection force stationed at every railyard, road junction and airport in Eastern Europe. In the case of MBFR a potential agreement is more a political symbol and would not appreciably alter the military balance making air-tight verification of little relevance.

Proposal Abstract J45.1(A84)

1. **Arms Control Problem:**
   (a) Regional arms control - Europe
   (b) Conventional weapons - ground forces

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   Orhaug, Torleiv. "International and Regional Satellite Monitoring Agency - A European Example". Paper presented at SIPRI-Tokai University Symposium on An International and Regional Satellite Monitoring Agency, Stockholm, Sweden, 24-26 September 1984.

4. **Summary:**

This paper focuses on some of the problems related to the use of satellite observations by an international or regional agency.

Space observations have been of great importance for surveillance, crisis monitoring and treaty monitoring. Only the superpowers have the capacity for extensive observations from space for military purposes. However, several other states are developing similar capabilities. Parallel to this, there is a growing civilian use of similar techniques.

The paper briefly reviews the military uses of space technology. Most current uses are "non-aggressive" and stabilizing. However, the majority of these functions also act as "force multipliers". The most effective way of satellite observation is to use electromagnetic radiation whether natural or man-made. The kinds of information acquired may be categorized by the rapidity of temporal change (time scale) of the phenomena. A large number of sensors are in use, most of which are image forming since they record both the electromagnetic radiation and the angle of incidence (a table summarizing satellite sensors is provided). The main characteristics of sensors are their resolution (ability to distinguish fine details) and range (ability to cover a wide range). These characteristics can be applied to three important parameters of an imaging sensor which influence, its quality: spectral (resolution and range), intensity (contrast accuracy and range) and geographical (spatial resolution and area coverage). High spatial resolution is needed for many military interesting targets and activities. The most important parameters for cameras are focal length, satellite altitude and film (detector) characteristics. (A table detailing the resolution required for various interpretation tasks is provided.)

Any satellite sensor is limited by observation repeatability, cloud and other atmospheric conditions, lighting conditions, camouflage, movable targets, and time delay of information.

The paper next turns to civilian uses of space technology. The course resolution of Landsat data can only be used for large ground features. Landsat data is generally analyzed using spectral features rather than the geometric features emphasized in ordinary photo-interpretation. Landsat data is in digital format permitting extensive use of computers for data manipulation and presentation. Mention is made of the French SPOT satellite which will have a resolution relevant for monitoring.

The information sources and corresponding technology used by the US for verification are examined. National technical means including ground-based, sea-based, airborne and space-based systems. The technical methods employed are:

(1) radars - line of sight - ground-based, sea-based, airborne
- OTH - ground-based
(2) infra-red sensors - space-based
(3) photographic sensors - space-based, sea-based
(4) interception of communication, radar and telemetry - ground-based, airborne, space-based, sea-based

Orhang next summarizes the applicability of satellite observation to verifying existing multilateral arms control agreements, identifying the contribution of satellite monitoring, the sensors and the resolution needed. He also cites several examples where the superpowers have apparently employed observation satellites to monitor crises and military manoeuvres. The possible tasks of a satellite monitoring agency (SMA) are summarized as:

(1) verification of existing and future international treaties,
(2) monitoring crisis areas,
(3) preventing crisis situations,
(4) settling disputes between countries,
(5) early warning of potential armed conflicts, and
(6) information for UN observers and peacekeeping forces.

Concerning crisis monitoring an SMA could provide information on changes in force strength, movement of forces, and deployment of aircraft and ships. However, there has been no indication that existing satellites have been a factor in inhibiting the outbreak of hostilities. An SMA with free information might affect world opinion and prevent a crisis in contrast to the present situation in which only the superpowers have satellite data.

An SMA would probably not make use of electronic reconnaissance satellites because this is a complicated subject requiring detailed knowledge of military communications and hardware. Cooperation from states is also unlikely in this field. The SMA would concentrate therefore on photographic and radar instruments. Such data could also be used for civilian purposes like environmental monitoring and resource management for cost-benefit reasons.

The International Satellite Monitoring Agency (ISMA) idea of France does not have the support of the superpowers. It is therefore interesting and reasonable to start with an intermediate step: a Regional Satellite Monitoring Agency (RSMA). Europe would be an appropriate region for an RSMA because of the high concentration of

armaments there, the possibility of confidence-building between two blocs of states as well as between individual countries, and the existence of space technology infra-structure (eg. the European Space Agency and Intercosmos).

The paper focusses on three tasks for the RSMA:

(1) verification/control of major military manoeuvres,
(2) control of crisis situations (fear of surprise attack), and
(3) the influence of the Air-Land Battle concept on satellite verification.

For each task Orhaug identifies the uses of the data, the targets of verification, and the appropriate data collection sensors including resolutions required.

Proposal Abstract J46(A82)

1. **Arms Control Problem:**
   Regional arms control - outer space

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Bogdanov, O.V. "Banning All Weapons in Outer Space". In Outer Space: A New Dimension of the Arms Race, pp. 325-329. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**
   This article comments on the Soviet 'Draft treaty on the prohibition of the stationing of weapons of any kind in outer space' (see abstract J47(G82)). The author suggests that the treaty could "well be verified" (p. 327) by national technical means of verification as provided for in Article 4. "Complex international infra-structures for control purposes" are unnecessary because technical innovations and the spread of technology will enable more and more countries to participate in control and verification activities. The author notes that the experience of monitoring the 1963 Test Ban Treaty shows that international machinery is not necessary because nations will acquire national means of verification over the years.

Proposal Abstract J47(G82)

1. **Arms Control Problem:**
   Regional arms control - outer space

2. **Verification Type:**
   (a) Remote sensors (Article 4(1) and (2))
   (b) Complaints procedure - consultation and cooperation (Article 4(3))

3. **Source:**
   Union of Soviet Socialist Republics. "Draft treaty on the prohibition of the stationing of weapons of any kind in outer space". CD/274, 7 April 1982. (Also submitted to the thirty-sixth session of the UN General Assembly as A/36/192, 11 August 1981).

4. **Summary:**
   The scope of this draft treaty is outlined in Article 1 which obliges parties "not to place in orbit around the earth objects carrying weapons of any kind, install such weapons on celestial bodies, or station such weapons in outer space in any other manner, including on reusable manned space vehicles...." Parties also undertake "not to destroy, damage, disturb the normal functioning or change the flight trajectory of space objects of other State Parties..." (Article 3).

   Article 4 of the draft treaty provides for the use of national technical means "in a manner consistent with generally recognized principles of international law", to verify compliance with the treaty. Under Article 4(2), parties would undertake not to interfere with such verification. Article 4(1) and (2) are similar to articles of the ABM Treaty and other bilateral agreements between the superpowers.

   The parties would consult each other, make inquiries and provide information in connection with inquiries in order to "promote the objectives and provisions" of the treaty under Article 4(3). No other complaints procedure is provided for in the draft treaty.

5. **Selected Comments of States:**
   The Netherlands (CD/PV.170, 8 April 1982) suggests that national technical means of verification, while satisfactory for a bilateral agreement, may not be adequate or acceptable for a multilateral treaty. Provision should be made for the possibility of the further internationalization of the verification of a treaty. The Netherlands also noted that the draft treaty does not provide for any recourse to international bodies concerning doubts or complaints about compliance or non-compliance with a treaty.

France (CD/PV.172, 20 April 1982) comments that the draft treaty provides only for national technical means of verification and does not consider a role for satellites which could be used on behalf of the international community (a proposal made by France and other countries - see abstract J5(G78)). France (CD/PV.184, 2 September 1982) also notes that the draft treaty is ambiguous as to whether the non-interference with national technical means of verification specifically includes satellites. France recalls that the SALT I agreement provides for non-interference with "national technical means of verification" and a declaration made by President Carter on 1 October 1978 interpreted that as specifically including satellites. France notes that there has been no corresponding Soviet declaration.

The Federal Republic of Germany (CD/PV.185, 7 September 1982) states that the Soviet draft treaty does not make any advances towards "an acceptable level of arms control in outer space".

Proposal Abstract J48(G83)

1. **Arms Control Problem:**
   Regional arms control - outer space

2. **Verification Type:**
   (a) Remote sensors - (Article 4)
   (b) Complaints procedure - consultation and cooperation (Article 5(1))
   - consultative commission (Article 5(2))
   (c) National self-supervision (Article 6)

3. **Source:**
   Union of Soviet Socialist Republics. "Soviet proposal for a draft treaty on the prohibition of the use of force in outer space and from space against the Earth". UN Document A/38/194, 23 August 1983.

4. **Summary:**

   This draft treaty would prohibit the use or threat of force "in outer space and the atmosphere and on the Earth through the utilization, as the instruments of destruction, of space objects in orbit around the Earth, on celestial bodies or stationed in space in any other manner". The use or threat of force against space objects is also prohibited (Article 1). Article 2 bans the testing or deployment of space-based weapons "for the destruction of objects on the Earth, in the atmosphere or in outer space". It also prohibits the use of space objects to destroy targets on the Earth, in the atmosphere or in outer space. Parties are obligated "not to destroy, damage, disturb the normal functioning or change the flight trajectory of space objects of other states". The testing and creation of new anti-satellite (ASAT) systems is proscribed and existing ASAT systems are to be destroyed. Finally, Article 2 prohibits the use of manned spacecraft for military, including anti-satellite purposes.

   Article 4 provides for verification by national technical means in accordance with "generally recognized principles of international law". States would undertake not to interfere with this means of verification (Article 4(2)). Article 4(1) and (2) are identical to articles of the ABM Treaty and other bilateral agreements between the superpowers.

   Consultation and cooperation through "appropriate international procedures within the United Nations and in accordance with its Charter" (Article 5(2)) would resolve problems related to the objectives and implementation of the treaty. Article 5(2) explicitly states that this "may include utilization of the services of the Consultative Committee". The provisions of Article 5 are similar to those of Article V of the ENMOD Convention.

Under Article 6, each party would undertake "to adopt such internal measures as it may deem necessary to fulfill its constitutional requirements" in order to ensure the implementation of the treaty by every jurisdiction under its control. It is similar to Article IV of the ENMOD Convention.

Proposal Abstract J49(A84)

1. **Arms Control Problem:**
Regional arms control - outer space

2. **Verification Type:**
(a) Remote sensors - satellite
(b) On-site inspection - selective
(c) Complaints procedure - referral to Security Council
(d) International exchange of information

3. **Source:**
Danielsson, Sune. "Approaches to Prevent an Arms Race in Outer Space". In Space Weapons: The Arms Control Dilemma, pp. 157-171. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**
This article begins with a review of existing rules of international law relating to space weapons contained in the UN Charter, multilateral treaties and bilateral agreements. Commenting on proposals for the prevention of an arms race in outer space, the author finds the Italian proposal in 1979 (see abstract O4(G79)) inadequate. The proposal does not contain any provisions for verification and the complaints procedure in the Security Council would be rendered ineffective by the veto power of the two superpowers. The Soviet proposal of 1981 (see abstract J47(G82)) is an improvement over the Italian proposal. It does not contain a provision for Security Council involvement in the complaints procedure. In Article 4 it provides for national technical means, however, this is still insufficient because this method cannot distinguish between a launcher for a non-military satellite from an ASAT system and cannot monitor aircraft-carried ASAT missiles. On-site inspection is necessary for such functions. The complaints procedure proposed by the Soviet Union is useful because it contains an obligation to supply information, but a more effective mechanism than simple consultations is necessary to make the provisions work.

The author offers his own proposals to ban military uses of space, ASAT weapons and the use of force in space. With regard to verification, he rejects national technical means as being insufficient and unavailable to many potential parties to a treaty. International verification involving some kind of on-site inspection would be necessary. The parties should build confidence with "openness" about national space activities. Freely available information could help solve problems concerning proliferation. Rules in the Outer Space Treaty (see abstract B24(T67)) and the Registration Convention (1975) about notification to the UN and information to the public should be made more comprehensive.

Proposal Abstract J50(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization

3. **Source:**
   Jankowitsch, Peter. "Arms Control in Outer Space: The Need for New Legal Action". In Space Weapons: The Arms Control Dilemma, pp. 173-184. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**

In order to promote security in space, treaty law should be developed and strengthened. Immunity of satellites for verification and military observation, as provided for by the principle of non-interference with national technical means of verification, should be broadened beyond the scope of bilateral agreements and should be clarified by explicit declarations. A declaration by President Carter on 1 October 1978 established a direct link between military observation satellites and national means of verification, but the Soviet Union has remained silent on the subject.

The author calls for international cooperation to develop alternatives to purely national technical means of verification. He supports the proposal to establish an International Satellite Monitoring Agency and draws attention to the report of a group of experts to the Second Special Session on Disarmament (see abstract J11(I81)) which found that such an agency would be technically, legally and financially feasible.

The author recommends that arms control in space could be accomplished by strengthening the 1967 Outer Space Treaty (see abstract B24(T67)) with additional provisions which would effectively prevent an arms race in space. A redrafted treaty could use some of the language of the 1959 Antarctic Treaty (see abstract B7(T59)). Acticle I prohibits all measures of a military nature and Article VII (3) renders all areas of Antarctica, including stations and points of entry, subject to inspection.

J50.1(A86)

Proposal Abstract J50.1(A86)

1. **Arms Control Problem:**
   (a) Regional arms control - outer space
   (b) Conventional weapons - ground forces

2. **Verification Type:**
   Remote sensors - ground-based
   - satellite

3. **Source:**
   Rutkowski, Chris A. The Role of Astronomical Instruments in Arms Control Verification. Arms Control Verification Studies, no. 2. Ottawa: Department of External Affairs, 1986.

4. **Summary:**
Astronomical instruments and methods have become increasingly used in military space research. It is also quite possible to use these same techniques for verifying arms control agreements related to space-based weapons and gound-based deployment of troops and weapons.

Satellite tracking programs are described, including: "MOONWATCH" which involved the use of civilians making visual observations, the Baker-Nunn camera system, photometric observation systems and the Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) system. There follows a short section outlining the resolution potential of various optical and radar systems.

The author then discusses developments in the area of space-based weapons, including Fractional Orbital Bombardment Systems (FOBS) as well as Directed Energy and other Anti-Satellite (ASAT) weapons. International agreements relating to the militarization of space are reviewed and the role of ground-based and space-based systems for monitoring these and other treaties is discussed.

Among the author's observations are:

(1) Satellite tracking is likely to become more important as the military use of space increases.
(2) Proposals for arms control verification in space should include the use of technology at the same level as the systems to be verified.
(3) As Baker-Nunn cameras used by the military are replaced by electro-optical systems, their transfer to astronomical institutions would be useful in the development of verification techniques in the academic sector.
(4) Spin-offs from military astronomical technology development should be realized by scientific institutions for asteroid tracking, binary-star resolution, quasar studies and other projects.

(5) Canada stands in a good position to contribute to ground-based verification studies on an international scale and possesses the necessary technical means, manpower and facilities to remain in such a position for the long term.

(6) If additional GEODSS stations were to be established, it would be useful to consider Canada as a possible site.

(7) Canadian astronomy, one of Canada's most prized scientific strengths, has been undermined by lack of modern equipment. If Canada participates in advanced technology projects, one spin-off advantage of such participation could be the application of astronomical technology to the verification of arms control agreements.

Proposal Abstract J50.2(G87)

1. **Arms Control Problem:**
   (a) Regional arms control - outer space
   - Europe
   (b) Conventional weapons - ground forces

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) International control organization - ISMA

3. **Source:**
   Canada. Department of External Affairs. The PAXSAT Concept: The Application of Space-based Remote Sensing for Arms Control Verification. Verification Brochure, no. 2. Ottawa: 1987.

4. **Summary:**

This brochure provides a general outline of Canadian research into the feasibility of applying space-based remote sensing for arms control verification. Two trends were recognized by the Canadian government in the early eighties: (1) the increasing capabilities of civilian space-based remote sensing and the growing number of countries involved in space; and (2) the increasing likelihood that significant multilateral arms control and disarmament agreements would be concluded requiring sophisticated multilateral verification.

Certain themes form core elements of the PAXSAT concept (PAX being Latin for "peace"):

(1) There must be a significant multilateral agreement to warrant the level of sophistication of technology and expenditure of funds required for the development of such an advanced verification system.
(2) Parties to such an agreement have the option to participate in its verification procedures.
(3) A PAXSAT system would be treaty specific; it would be used only with respect to agreements to which it expressly applied as part of an overall verification process for those agreements alone.
(4) The treaty being verified would establish the requisite political authority for the verification mechanism and its operation.
(5) Technology requirements would be met by the collectivity of participants and would not depend upon or call for superpower participation, although the treaty would be open to all states.
(6) PAXSAT should be based, to the greatest extent possible, on existing openly available technology without requiring major costly improvements. The technology possessed by the Canadian commercial sector was used as a base for the PAXSAT studies.

The brochure briefly outlines two research projects:

(1) PAXSAT 'A' which examined whether a space-based observation system could help verify an outer space arms control regime, and

(2) PAXSAT 'B' which examined the application of space-based remote sensing for verifying controls on conventional weapons in a regional context, using Europe as a case-study.

Proposal Abstract J51(A78)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors
   (b) International exchange of information - reports to international body
   (c) Complaints procedure - consultative commission

3. **Source:**
   Scoville, Herbert, Jr., and Kosta Tsipis. Can Space Remain A Peaceful Environment? Muscatine, Iowa: The Stanley Foundation, July 1978. Occasional Paper, no. 18.

4. **Summary:**

The authors review the current and future US and Soviet capabilities in space and the potential for space warfare. They call for an agreement aimed at prohibiting further testing, deployment or use of any Earth-based or space-based systems designed to damage, destroy or interfere with the functioning of any spacecraft of another nation. Such a prohibition, however, could encourage the use of space for deploying dangerous military systems, by guaranteeing their invulnerability. Therefore such an agreement should also include a ban on the stationing in orbit, on celestial bodies or elsewhere in outer space of weapons designed to inflict injury or damage on Earth, in the atmosphere or on objects launched into space.

Verification problems will primarily arise from the difficulty of differentiating between legitimate and proscribed space activities. It is therefore important to include in the treaty supplemental mechanisms of facilitating verification. The authors recommend mandatory reports to the UN by states launching spacecraft. This would ensure greater timeliness and more detailed information in contrast to the current voluntary reporting system. Information reported would include the mass and orbits of the objects, changes in orbital characteristics and notification of anticipated reentry. Current and improved national technical means could be used to check the accuracy of the reports.

Ambiguities would still arise, therefore the UN should also establish a multinational body, similar to the bilateral US/USSR Standing Consultative Commission, to consider questions of compliance. This body would not have the power to rule that a violation had occurred but only to bring to the attention of all parties the pertinent facts.

Proposal Abstract J52(A83)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   Remote sensors - satellite
   - ground-based

3. **Source:**
   Barry, J.N. "Application of Space and Remote Sensing Technology to Verification of Weapons Systems for Use in Outer Space." In Compliance and Confirmation: Political and Technical Problems in the Verification of Arms Control of Chemical Weapons and Outer Space, pp. 97-111. Edited by H. von Riekhoff. Ottawa: Norman Paterson School of International Affairs, Carleton University, 1986.*

4. **Summary:**
   This study looks at the problems of verifying agreements concerning existing and projected anti-satellite weapons systems. An attempt is made to "analyse the application of space technology and remote sensing techniques" (p.3) to that problem within certain specified parameters. In order to design a system which is within the technological capability of third parties, this proposal relies on modest technology, realistic timeframes and measures which might fall within the "practical bounds of the political process". The mission was selected accordingly - the most effective and simplest means of verification in this instance was found to be through space-based surveillance of anti-satellite weapons systems, given that increased distance places high technological demands on a system and must be more comprehensive in order to be effective.

   The task which is to be fulfilled by the proposed systems "involves surveillance activities which the one major power cannot impose upon the other without provocation or retaliation" (p. 6). In this manner, it is hoped that the United Nations might fill the gap in surveillance and act as a "considerable stabilizing influence". In order to determine the best possible means of verifying the existence of anti-satellite weapons from space, a matrix is designed which compares remote sensing capabilities with the various components, configuration and life cycle of these weapons. The kinds of remote sensors listed are: visible and infra-red sensors, radar, passive electromagnetic sensing of radar and other man-made signals, and sensors that detect nuclear radiation, chemicals, and electric potential.

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* Proceedings of a conference held in 1983.

The purpose of this matrix is to compare the effectiveness of various remote sensors against individual stages in development and different weapons configurations. On the basis of this evidence, it is concluded that remote sensors are much more effective from satellite platforms than ground-based stations. They are also more cost-effective, the most revealing, and the least demanding in terms of technology. A potential spacecraft is then devised with this mission in mind which would "utilize low energy, high efficiency thrust techniques to move a spacecraft to successive stations for investigations" (p.17). It would move close to its target as informed by ground-based stations, assuming that investigations are to be conducted in "periods of non-hostility" and will focus on spacecraft that are "parked in orbit".

This system cannot operate in isolation, but instead relies on a number of support systems. Among these are ground-based targeting and tracking systems, a computer inventory of space-based objects to facilitate identification, the availability of launch facilities and other spacecraft to provide data links. In terms of manpower support, heavy demands will be placed on operation and control, data reduction must be accomplished through some sort of screening process, and finally the resultant data must be interpreted.

Lastly, some areas are identified as warranting future study. The international legal implications of this proposal for verification and the nature of the requisite organizational support and infrastructure ought to be considered in greater detail. More attention might also be given to the applicable payload technologies and a more refined definition of the spacecraft and mission.

Proposal Abstract J52.1(A83)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASAT

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Pike, John. "Verification of Limits on the Soviet Anti-satellite Weapon - A Staff Study". Reproduced in Congressional Record (21 July 1983): H5415.

4. **Summary:**

Verification is properly a key issue in the control of the arms race in outer space. Three types of activity may be the focus of arms control limitations: possession, testing and deployment.

(1) Possession: In recognition of the difficulties of verifying possession, most existing arms control agreements focus on testing and deployment. An untested system that is not deployed is little actual threat. "Given the marginal performance of the Soviet ASAT, the possession of even a large number of the actual orbital intercept vehicles would pose little threat, in the absence of a significant deployment of delivery vehicles".

(2) Testing: Launching of the Soviet ASAT is readily observable by US early warning satellites. The ASAT, once in orbit, is tracked by a variety of ground-based radars and cameras. The intercept manoeuvres are easily distinguished from other satellite activities. The telemetry from the ASAT is monitored by ground and space systems. Testing of the Soviet ASAT is therefore readily verifiable.

(3) Deployment: The ASAT launch vehicle is 10 feet in diameter and 150 feet long, 30 feet longer than an SS-18 ICBM. It is readily observable and distinguishable. The use of other launch vehicles for the present Soviet ASAT is unlikely.

Based on existing launch pads alone, a campaign against all 18 US satellites in low Earth orbit would require several weeks to complete. Such a capability is likely to be of limited interest to the USSR. Any expansion to these launch facilities would be readily observable.

Basing the Soviet ASAT in missile silos would require extensive modification to the silo, the construction of additional facilities and a changed pattern of activity which would be readily observable. Training and testing would also be observable. Since the utility of silo ASAT basing is low and its verifiability high, the Soviets are unlikely to pursue this option.

"Thus, a ban on deployment of a significant and militarily useful ASAT force could be verified with a high degree of confidence." While a small number of Soviet ASATs could be hidden, the actual combat potential of such cheating is very small - "the ability to destroy one or two satellites in low orbit over a period of a few days". This threat is about the same as that posed by manoeuvrable spacecraft belonging to the Soviet manned program and that posed by the Galosh ABM system. Neither of these systems is a significant threat and the capability of US NTMs"to detect any ASAT deployment with a capability greatly in excess of this is fairly good."

Proposal Abstract J53(A83)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   Remote sensors - satellites

3. **Source:**
   Covault, Craig. "Soviet Anti-satellite Treaty Raises Verification Issues". Aviation Week and Space Technology August 29, 1983.

4. **Summary:**
The US response to the Soviet Union's proposed anti-satellite (ASAT) weapons treaty is reviewed in this article, and recent weapons developments which might affect negotiations are enumerated. The proposal itself was rejected by the US on the grounds that it did not make adequate provisions for verification. Test ban proposals were rejected by the US since they believe that the USSR currently possesses anti-satellite laser weapons, and consequently would be able to maintain their advantage under the treaty. There is some concern that these systems are already tested and could be "hidden from reconnaissance satellites under the proposed treaty language". Existing ASAT systems may be difficult to eliminate given the small size of their warheads. Finally, problems in verification were perceived with regard to proposals for non-interference with other nations' space objects, since it could be difficult to discover who actually perpetrated a given act.

J54(A83)

Proposal Abstract J54(A83)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors
   (b) International exchange of information
   (c) International control organization

3. **Source:**
   Gilman, E. Banning Weapons in Outer Space; Pros and Cons of an ASAT Treaty. Ottawa: Operational Research and Analysis Establishment, Department of National Defence, 1983. Project Report No. 234.

4. **Summary:**

This paper discusses the possible advantages of a ban on anti-satellite weapons and the obstacles to an arms control treaty for space. Verification is denoted as an important function given the small number of satellites in existence from which any loss could be decisive. It may be difficult to determine the various kinds of satellites and their functions, and disguised ASAT launchers may be similarly indistinguishable.

Notwithstanding such problems, it is asserted that an ASAT treaty may be monitored since the "Soviet weapon has distinct characteristics which make it relatively easy to observe and track" (p.19). The identification of satellites may also be facilitated through provisions for the registration of all satellites and information exchange regarding satellite launches, physical makeup, manoeuvrability, longevity, orbital paths and functions. Some sort of Standing Consultative Commission similar to the SALT model might be established which would review and update guidelines for an ASAT agreement. It is concluded that "in spite of everything, a treaty may still not prevent an ASAT breakout" (p.20), but it might serve to reduce the effectiveness of and confidence in such weapons.

Proposal Abstract J55(A83)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   Remote sensors - ground-based
   - satellite
   - radar

3. **Source:**
   Hafner, Donald L. "Outer Space Arms Control: Unverified Practices, Unnatural Acts?" <u>Survival</u> 25, no. 6 (November/December 1983): 242-248.

4. **Summary:**

Hafner proposes a "no new types" limitation for anti-satellite (ASAT) weapons. Such an agreement would allow the US and Soviet Union to retain their current ASATs but would prohibit further modernization of those systems. Verification of an agreement would be difficult, but "verification problems should not be over-emphasized" (p. 246). Particular verification concerns consist of the following issues: can the permitted ASAT be modified to permit access to significantly higher altitudes and can other, more effective ASATs, be acquired covertly? The first issue does not create a problem because the fuel required to reach higher altitudes would necessitate the addition of potentially verifiable larger boosters. The Soviet ASAT has already been tested up to 2,400 km, the range of all low-orbit satellites. The next set of important US satellites is stationed at 20,000 km which is beyond the range of a marginally improved Soviet ASAT. The second issue causes greater concern because of the potential for secretly combining existing systems with new, more powerful boosters. Other possibilities exist for the development of a new ASAT, for example an orbiting laser or a miniature ASAT interceptor similar to the US version. However, these systems would need to be tested which involves a substantial risk of detection by US verification systems.

Monitoring space activities and objects at very high altitudes poses significant problems for the US. The reach of ground-based radars and their powers of resolution are limited. The US Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system will improve American capabilities by providing "precise, highly detailed optical and orbital signature data on man-made objects approximately 5,500 km from Earth and beyond", but the system will not be operational until 1987 and even then each of the five sites will apparently be able to monitor only half of the sky overhead. However, North American Air Defense (NORAD) radars have recently been upgraded and upgraded radars in the US, Turkey and the Pacific will be able to perform monitoring tasks at distances out to geosynchronous orbits.

J56(A84)

Proposal Abstract J56(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - radar
   - satellite
   - ground-based

   (b) International exchange of information
   (c) Complaints procedure - consultative commission

3. **Source:**
   Gottfried, Kurt. "An ASAT Test Ban Treaty". In Space Weapons: The Arms Control Dilemma, pp. 131-144. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**

Gottfried presents and discusses a draft treaty limiting anti-satellite weapons. The treaty would ban testing in space "or against space objects, weapons that could destroy, damage or change the flight trajectory of space objects, or space weapons that can damage objects on the ground or in the atmosphere" (p.131). Verification would be by national technical means. Cooperative measures, as provided for in articles 3 and 4 of the draft treaty, to improve the effectiveness of verification, implementation and compliance would take place in the Standing Consultative Commission established by the SALT I agreement in 1972. Article 5 of the draft treaty requires the parties to begin negotiations on limiting and reducing ASAT weapons as soon as the test ban is in place.

A more comprehensive ban on ASAT possession would be desirable, but would be extremely difficult to verify. Verification of the dismantling of interceptors used by the Soviet Union would be impossible without highly intrusive on-site inspection. The American ASAT system, launched from an F-15 aircraft, is almost unverifiable because of its small size and mobile basing mode. However, American surveillance systems could monitor a test ban. The US has recently upgraded the Northern Air Defence (NORAD) radar system and has enhanced it with new radars based in the Pacific. In addition, the US Ground-based Electro-optical Deep Space Surveillance (GEODSS) system will be able to provide highly detailed data on small objects at distances of more than 5,000 km when it becomes operational in 1987. The parties should develop manoeuvrable space vehicles mounted with telescopes to photograph and track manoeuvring space vehicles, measure the infra-red emission of space objects to see whether they were targeted by lasers and monitor permitted space activities which could hide clandestine ASAT tests.

Other provisions of the draft treaty would contribute to confidence in verification. Article 4.1(6) provides for the parties to furnish, on a voluntary basis, information to assure confidence in compliance. This could include prior notice of Soviet space launches from pads which can launch the ASAT interceptor. The parties could also establish rules to limit movements of space vehicles and the encoding of telemetry, to provide for prior announcements of certain space activities and to permit close approaches by the other party's surveillance vehicles.

Although the ability to verify an ASAT test ban would be imperfect, protective measures such as satellite manoeuvrability and redundancy (space satellites, decoys and ballistic missiles with payloads that can perform satellite functions) would generate confidence in the utility of an ASAT test ban. Unconstrained ASAT competition would be costly and would leave both sides' satellites vulnerable to attack.

Proposal Abstract J57(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Grey, Jerry. "The Case for Defensive Deterrence". Disarmament 7, no. 2 (summer 1984): 83-91.

4. **Summary:**

In discussing the merits and feasibility of defensive deterrence, Grey examines obstacles to establishing a missile defence, namely the 1972 ABM Treaty (see abstract J67(T72)) and a possible anti-satellite (ASAT) treaty. He suggests that the ABM Treaty could be renegotiated to permit developments in missile defence technology. An ASAT treaty appears unverifiable without mutual on-site inspection which is probably unacceptable. National technical means cannot determine whether spacecraft activity constitutes an ASAT weapon test or whether an "innocent-looking" air-to-ground missile might be an air-to-satellite missile. The Soviet ASAT weapon is orbited by an SS-9 ICBM, but other ICBM launchers could probably perform the same function, thereby complicating verification. The American ASAT weapon, launched from an F-15 aircraft, could be disguised as an air-launched missile and only an inspection of its guidance system would reveal its ASAT function.

Since anti-ballistic missile weapons could also knock out satellites, "an ASAT specific treaty would be worthless" (p.91) without a verifiable ABM agreement. For these reasons among others, the United States should not seek to negotiate an ASAT ban. ASAT weaponry may in fact improve deterrence and does not necessarily render all satellites totally vulnerable.

Proposal Abstract J58(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ground-based
   - radar

   (b) On-site inspection - selective
   (c) International exchange of information

3. **Source:**
   Guionnet, Michel. "Verification Possibilities Should an ASAT treaty Materialize". In Space Weapons: The Arms Control Dilemma, pp. 193-196. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**
A treaty banning the development, manufacture and use of anti-satellite (ASAT) weapons is desirable, but will be very difficult to verify. ASAT tests, deployment of space mines or of large radiation transmitters from the ground or from space can be monitored "with some degree of confidence" (p.196), but existing ASAT systems waiting for launch cannot be monitored. Only agreement to allow cooperative measures and 'close-look' or on-site verification will be effective, and even then not with regard to existing stocks.

Various techniques can allow monitoring of the use of ASAT weapons. Ground-based optical or radar observation equipment would be able to detect an aggressive head-on collision which destroys a satellite or alters its trajectory. A 'black box' mounted on board the satellite could detect pellet spraying, laser beam heating or irradiation and could relay information to the ground. Hardened black boxes are probably already carried by military satellites, but hardening civilian satellites and fitting them with black boxes would be economically inefficient. Recovery and examination of satellites for evidence of an attack is another option, but this is currently possible for spacecraft in low Earth orbit only. It is likely that special satellites to spy on other satellites will be developed.

ASAT systems of the 'rendezvous' type use an interceptor vehicle which collides with a satellite or explodes nearby. The testing of such a system can be detected, so it could be subject to verification. However, rendezvous manoeuvres for peaceful purposes could conceal a test and this could not be detected without 'close-look' observation of the approach conditions. If development of these systems were permitted, verification would be impossible because ground store checks would be useless. Interceptor vehicles can be stored and launched in the same way as other satellites.

Detection of pre-positioned space mines would be possible with existing surveillance systems. The US Ground-based Electro-Optical Deep Space Surveillance system can detect objects the size of a football in geosynchronous orbit.

ASAT systems using ground-emitted beams can be of two types. 'Disruptive' systems prevent a satellite from operating but do not destroy any part of it. Electromagnetic jamming stations will resemble telecommunications facilities, but the electronic intelligence satellite network may be able to detect aggressive actions. 'Destructive' systems cause irreversible damage to the satellite. These systems will utilize a very high energy beam. National technical means will be able to detect and monitor such systems if explicit criteria can distinguish them from anti-missile protection systems or anti-aircraft systems. On-site inspection would not be possible in this regard because of the sensitive military nature of such functions.

ASAT systems using space-emitted beams will require several spacecraft and large power sources using nuclear reactors and heat dissipating devices. The presence of these features will make verification possible. In the future, when material processing stations and space stations are commonplace, satellite observation with 'close-look' capabilities will be necessary to distinguish functions. Laser systems will utilize large focusing mirrors; such features may be considered as functionally related observable differences (FRODs) and can facilitate verification, but less characteristic space-based 'disruptive' systems would be more difficult to verify.

Other methods could strengthen verification. Parties could supply detailed information about space objects to be launched and could be asked to supply characteristics which prove that the system to be launched cannot be used against satellites. A provision prohibiting the encoding of spacecraft telemetry could also ensure that parties have access to information about the objects.

Proposal Abstract J59(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar
   - ground-based
   (b) On-site inspection - selective
   (c) International exchange of information
   (d) International control organization - ISMA

3. **Source:**
   Hafner, Donald L. "Approaches to the Control of Anti-satellite Weapons". In National Interests and the Military Use of Space, pp. 239-270. Edited by William J. Durch. Cambridge Mass.: Ballinger Publishing, 1984.

4. **Summary:**

The author considers various possible arms control agreements for outer space, which range from complete demilitarization to a specific ban on anti-satellite (ASAT) weapons, and relevent considerations for verification. He is skeptical about American verification capabilities, but does not rule out the desirability of an outer space arms control agreement.

The complete demilitarization of outer space would pose the most significant problems for verification. All satellite launchers would have to be checked to verify that they did not have the capability to perform forbidden functions and that they did not carry banned equipment intended for later use. Verification would also have to ensure that data from civilian satellites was not being diverted for military purposes. A verifying party would have to certify that the other side was not storing prohibited satellites for use in conflict.

Partially demilitarizing space, for example permitting some systems such as reconnaissance satellites while banning radar satellites used for targeting forces, would be somewhat easier to verify, but would still create verification problems. Many threatening satellites have observable, distinctive characteristics such as large optics or antennas, identifiable radio frequency signals and distinctive orbital features which could permit identification, but modified satellites or new systems may not possess these characteristics and therefore may not be verifiable from a distance.

Satellites could be placed under bilateral or international control. An ISMA or a jointly-manned US-Soviet crisis center could supervise "desirable" satellite activities. Either of these schemes would have to address the issue of procedural safeguards for the

collection and dissemination of satellite data. Information which could be used for "threatening purposes" should either be completely denied to the Soviets and Americans by a third party control group or provided to both superpowers equally. The US would probably be reluctant to enter into either of these arrangements because an international regime would not be responsible for protecting US security and a bilateral exchange of information would benefit the Soviets more because of the higher quality of American data.

Prelaunch inspection of space vehicles would not be acceptable unless the parties had agreed to the complete demilitarization of space. If there is only a partial ban on some military satellite functions, each side will want to protect the secrecy of systems which are permitted, therefore on-site inspections would not be acceptable. International inspections would also be rejected because neutrality and responsibility could not be guaranteed and the technical expertise to perform such inspections would be hard to find in genuinely neutral countries.

The standard of verification for a ban on the testing, deployment and use of ASATs should be high because the significance of a violation could be substantial. Even verification of the dismantling of existing Soviet ASAT interceptors would be inadequate because this would not provide assurance against the covert production of new ASATs. Permitted systems such as nuclear armed ICBMs and ABM interceptor missiles could also be used as ASAT weapons. Laser weapons, manned Soyuz vehicles, Progress resupply vehicles and a future Soviet space shuttle could also be used to destroy American satellites. Since a ban on many of these systems would infringe upon the peaceful uses of space, "it seems that a strict ban on ASATs faces insurmountable verification obstacles" (p. 224).

Even if it could not be verified with a high degree of confidence, a ban on ASAT testing should be pursued to strengthen a ban on the possession of ASATs. The US already knows the characteristic test pattern of the Soviet ASAT and could detect such tests with surveillance systems surrounding the Soviet Union. Attempts to disguise covert ASAT tests might be deterred by the fear of detection.

Banning new types of ASATs might be hard to verify. Modifications of existing ASATs would probably yield little advantage, though. Extra fuel to increase range would require larger boosters which could be detected. The current Soviet ASAT which has been tested up to 2,400 kilometres (the level of low-orbit US satellites) would have to be improved more than marginally to reach the second set of important American satellites at an altitude of 20,000 kilometres. Modifications of other systems to give them an ASAT capability would probably not be worth the effort. Ground- or air-based lasers could blind unprotected optical sensors at higher orbits, but would be able to physically damage only the lowest satellites. Concealing tests of an illicit high altitude ASAT test would be politically risky.

American radar tracking capabilities are constantly being upgraded, but are currently deficient in high altitude monitoring. A "no new-types" ban might create verification problems in this area.

Upgraded radars in the United States, Turkey and the Pacific will be able to monitor objects out to geosynchronous orbits, but their field of view and resolution powers are limited. The American Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system will enhance radar capabilities and yield highly-detailed data on objects 5,500 km from Earth and beyond, but will not be functional until 1987 and even then will be able to observe only half of the overhead sky.

A "rules of the road" agreement which permits the possession and testing of ASATs but bans their use would also be difficult to verify because it would require constant observation of all sectors in space to check for attacks on or interference with satellites. Hafner feels that, with any agreement, "doubts regarding verifiability are clearly a major obstacle" (p. 226). However, verification should be reassessed in the light of new monitoring capabilities being developed by the Air Force's Space Command. Nonetheless, a good satellite defense program and vigilance are essential complements to an outer space arms control agreement.

Proposal Abstract J60(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Jasani, Bhupendra. "The Arms Control Dilemma". In Space Weapons: The Arms Control Dilemma, pp. 28-38. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**

In this chapter, Jasani examines the implications of an anti-satellite arms control treaty. He reviews the legal provisions of existing treaties which are relevant to arms control in space and concludes that an ASAT treaty is necessary because existing treaties protect only some military satellites and leave civilian satellites totally vulnerable. He briefly discusses three new ASAT arms control proposals (see J47(G82), J48(G83), J61(A84)) and recounts the provisions of the 1972 ABM Treaty.

Verification of an ASAT treaty would not be impossible. While the US has deployed satellites in a wide range of orbital inclinations, the Soviet Union has used a much narrower range. Therefore, with an ASAT ban, the US would be alerted for detecting Soviet space vehicles in orbits traditionally used by the US. Both countries use the geostationary orbit (36,000 km), but the maximum range of the present Soviet ASAT system is about 1000 km so it is not a threat. Other ASAT weapons would probably be large and easily observable in their early stages of development. However, the American direct ascent ASAT system will pose problems for verification because of its small size and flexible launching capability. A ban on its deployment would be very difficult to verify.

Proposal Abstract J61(A84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors
   (b) Complaints procedure - consultative commission
   - consultation and cooperation

3. **Source:**
   Union of Concerned Scientists. "A Treaty Limiting Anti-satellite Weapons". In Space Weapons: The Arms Control Dilemma, pp. 142-144. Edited by Bhupendra Jasani. London: Taylor and Francis, 1984.

4. **Summary:**

   Under this draft treaty - each party would undertake "not to destroy, damage, render inoperable or change the flight trajectory of space objects of other States" (Article 1). Testing and deployment of weapons for these purposes is prohibited (Article 2).

   Article 3(1) provides for verification by "national technical means". This method would be supplemented by cooperative measures agreed upon in the Standing Consultative Commission (Article 3(2)). Parties would undertake not to interfere with national technical means of verification (Article 3(3)) nor to use deliberate concealment measures (Article 3(4)). Paragraphs (1) and (3) are identical to paragraphs (1) and (2) of Article XII of the ABM Treaty (abstract J67(T72)) and paragraph (4) is very similar to Article XII(3).

   This draft treaty would make use of the existing Standing Consultative Commission (Article 4). Within the Standing Consultative Commission the parties would:

   (1) consider ambiguities relating to compliance;
   (2) provide information to assure confidence in compliance;
   (3) consider questions involving unintended interference with or impeding of national technical means of verification;
   (4) consider cooperative measures for improving verification by national technical means;
   (5) consider possible changes in the strategic situation which have a bearing on the treaty; and
   (6) consider proposals for amending and increasing the viability of the treaty.

   The elements of Article 4 except (d) derive from Article XIII of the ABM Treaty.

J62(G84)

Proposal Abstract J62(G84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors
   (b) International exchange of information
   (c) Complaints procedure

3. **Source:**
   Union of Soviet Socialist Republics. "Answers by Mr. K.U. Chernenko to questions by a United States journalist Mr. J. Kingsbury-Smith". CD/510, 18 June 1984.

4. **Summary:**
   General Secretary Chernenko suggests that a freeze on anti-satellite weapons could be effectively verified by national technical means:

   > Effective verification of compliance by the parties with a moratorium on orbital-effect anti-satellite weapons could be assured by the means for the tracking of space objects which the parties have at their disposal. As regards sub-orbital-effect anti-satellite systems, use could be made, in addition to those already mentioned, of other United States and Soviet radio-electronic devices deployed on land, in the Pacific Ocean and in space. In unclear situations, there could be exchanges of information and consultations. If necessary, other forms can also be found.

Proposal Abstract J63(G84)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ground-based
   (b) On-site inspection - selective

3. **Source:**
   United States. Congress. Office of Technology Assessment. Arms Control in Space: Workshop Proceedings. Washington, D.C.: US Government Printing Office, May 1984. BP-15C-28.

4. **Summary:**

This report considers current anti-satellite capabilities and prospects for arms control in space. It is stated that the goals of verification in space are: (1) to reduce the vulnerability of 'space assets', (2) to impede the development of an adversary's ASAT capability, (3) to ease tensions between the superpowers, and 4) to prevent an arms race in space. The requisite level of verification may then be determined according to the purpose it will serve.

Some complicating factors in the verification process which are unique to arms control in space may be discerned. The enormous volume of space is difficult to monitor in its entirety, but the airspace of the Soviet Union is relatively well-determined, so that space surveillance of this particular area is possible. The task of verification is also complicated by the large numbers and variety of Soviet spacecraft, whose functions, activities and capabilities may not be readily distinguished. Finally, it may be difficult to ban that ASAT capability which is a residual function of other space-based systems, since it could go undetected. Further, it is quite likely that both sides would be unwilling to surrender the ability to utilize existing spacecraft in an ASAT mode where the capability exists.

Conversely, the verification process may be simplified by the fact that space is "transparent and accessible to monitoring, and weaknesses in ground-based monitoring systems can be mitigated by putting these systems into space" (p. 41). The incorporation of functionally related observable differences (FRODs) into spacecraft will facilitate identification, and all launches may be accounted for by monitoring ground sites and launch facilities. Testing and development of spacecraft can also be monitored by intercepting transmitted data.

The prospects for verification are then considered for individual ASAT modes and capabilities. The verification of those weapons placed in space is considered in theory, although neither the US nor the

Soviet Union currently has a "fully capable, dedicated, tested system in space". These launches would be visible, orbiting vehicles could be tracked, and suspicious rendezvouz missions would be noticed. Those Soviet ASATs which are already in existence still require extensive testing which could be monitored fairly easily, and the efficacy of any makeshift ASAT capability would likewise be mitigated by the absence of testing. "One can never rule out the existence of some covert, improvised ASAT capability of this sort but one can deny high confidence in such a system by preventing tests" (p.42).

It is asserted that nuclear ICBM and ABM missiles used in an ASAT mode do not pose a significant threat since the Soviets are not likely to use nuclear weapons in space. There is some chance that non-nuclear ICBMs and ABMs may be used in an ASAT role, but again, it is likely that such testing would be detected. Finally, space-based directed energy weapons may be used, but their operation and testing would most likely be detected, as lasers would be quite large and "may emit hydrogen fluoride and other gases" which could be detected (p.44).

It is concluded that cooperative verification measures should be established which would greatly assist arms control in space. Some form of in-orbit inspection could determine whether a satellite possessed nuclear weapons, although some problems might arise where the capabilities and functions of an inspection satellite might in itself be perceived as a threat.

Proposal Abstract J64(A85)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - ground-based
   - radar
   - satellite
   - ELINT

   (b) On-site inspection - selective
   (c) Short-range sensors - monitoring devices
   (d) Complaints procedure - consultation and cooperation

3. **Source:**
   Durch, William J. "Verification of Limitations on Anti-satellite Weapons". In <u>Verification and Arms Control</u>, pp. 81-106. Edited by William C. Potter. Lexington, Mass.: D.C. Heath and Company, 1985.

4. **Summary:**

After reviewing developments in anti-satellite (ASAT) technology and past attempts to discuss limitations on ASATs, the author considers the requirements for any ASAT limitation agreement. The first task is identifying and defining the objects to be controlled. In this regard, the most frequently discussed systems with residual ASAT capabilities are manoeuvrable spacecraft (both manned and automated), nuclear armed ballistic missiles and anti-ballistic missiles.

There are many monitoring instruments available to help verify an ASAT agreement. Photographic and electronic intelligence would be useful for monitoring ground-based ASAT-related activities. The United States also possesses an extensive ground-based space tracking system with radars and high-powered imaging systems. Table 5-1 (p.89) lists the components of this system. The observation powers of the main telescopes of the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system are such that the system can detect an object about the size of a soccer ball at geosynchronous range (36,000 km). US ground-based optical surveillance systems demonstrated resolution powers capable of imaging damaged tiles 20 cm long on the space shuttle <u>Columbia</u>. Space-based radars could be used to track space objects, but effective use of these systems may have to await the development of space nuclear power reactors to supply sufficient energy. Until this occurs (possibly in the latter 1990s), American space-based surveillance systems are likely to use passive infra-red sensors which require much less power than radars.

Standards for verification should depend on the military significance of possible violations. "Risk" should be evaluated in

terms of "probable threat" not just "bounded uncertainty". Uncertainty should be weighed against the offsetting benefits of arms control. For example, an agreement requiring the dismantling of the current Soviet ASAT might involve monitoring uncertainty with low risk since, in the absence of agreed constraints, Soviet deployments of more capable ASATs would be quite likely.

Durch considers the implications for verification of three types of possible agreements: (1) an agreement requiring the dismantling of existing weapon systems and a ban on testing; (2) a ban on ASAT tests in space or against space objects; and (3) an agreement which allows each side to retain one current type or one "generic" type of ASAT. In the first case, monitoring problems would be eased somewhat because a complete ban is easier to monitor than an agreement which allows operational units which must be counted or measured against agreed performance limitations. However, national technical means of verification would have difficulty verifying the dismantling of existing systems. The small size of the US F-15 launched ASAT (5 metres long) makes it difficult to observe and a covert ASAT capability could theoretically be retained anywhere F-15s are deployed. On the other hand, violations could be considered improbable because of the limited capabilities of the current Soviet ASAT and the residual ASAT capability available to both sides in electronic countermeasures and treaty-permitted ballistic missile defenses. Furthermore, the military value of covertly retained ASATs would decrease in the absence of testing. As a result, verification of this type of agreement could be less stringent than might otherwise be necessary.

An ASAT test ban would reduce confidence in ASAT capabilities and thereby deter their use without requiring their dismantlement. Effective verification of this type of agreement would depend on a satisfactory definition of "space" so that high altitude tests below a unilaterally defined threshold of space would not be possible. Durch concludes that "the US ability to monitor Soviet ASAT tests appears adequate to support a test ban" (p.95). Tests of ground-based lasers could be detected by monitoring the optical and thermal signatures of satellites which pass over known test ranges and comparing the signatures with baseline figures. Detecting space-based ASAT laser tests would be easier. Space vehicles equipped with lasers would likely be placed in low orbit because of their large size and could be observed by US Air Force telescopes. Features such as a large fuel supply, pointing and tracking telescope and large fighting mirror would readily identify the vehicles. Chemical lasers would probably be enveloped in a cloud of discharged gases which can be observed.

Verification of limitations which allow one ASAT system would be more difficult. Confining ASAT capabilities to low earth orbit would be important because ocean surveillance and photoreconnaissance satellites can monitor that region. Most early warning and communication satellites, however, would be out of range.

Modernization of an existing system would be hard to detect and evaluate. One solution is a "one generic type" approach in which ASAT weapons would be required to conform to certain standards specified in a treaty. Parties could then modify and modernize systems within those standards.

Another approach to ASAT limitations might be conducive to effective verification. A "rules-of-the-road" agreement modelled on the US-Soviet Incidents at Sea Agreement of May 1972 could specify prohibited types of behaviour occurring in space or affecting space objects. Specific measures could include launch constraints, speed of approach limits, minimum separation between spacecraft, on-site or space inspection and consultative mechanisms. Some of these measures would be particularly useful to deter or detect the use of "space mines".

On-site inspection would be of limited value for verification. *Ad hoc* inspections of launch sites would not detect violations of treaty provisions concerning production and storage of boosters, for example, when the activities occur off-site. Locating targets for inspection poses another problem. The US F-15 launched ASAT could be stored anywhere F-15s are deployed. Space mines could be carried by any space vehicle. Intrusive inspections might be opposed so automated systems in black boxes for monitoring certain activities could be useful even though these sensors would have a limited capability for identifying prohibited equipment. A space inspection regime modeled on the Antarctic Treaty (see abstract B7(T59)) might be useful for verifying demilitarization of space, but more limited measures could be verified by national technical means, making such inspection redundant.

Consultative mechanisms in the form of confidential government to government arrangements would be essential to legitimize questioning and would require parties to account for ambiguous activities.

Durch recommends pursuing an indefinite test ban on both kinetic and beam weapons along with a rules-of-the-road agreement. He concludes that "not every aspect of Soviet behaviour relevant to such an agreement could be monitored, but the risks posed by such unmonitored behaviour seem acceptable..."(p. 102).

Proposal Abstract J65(A85)

1. **Arms Control Problem:**
   (a) Regional arms control - outer space - ASATs
   (b) Nuclear weapons - ballistic missiles
   - cruise missiles
   - research and development
   - missile tests

2. **Verification Type:**
   (a) Remote sensors - radar
   - ground-based
   (b) Complaints procedure - consultative commission

3. **Source:**
   Kane, Gordon. "Verification of Testing Limitations on New Strategic Systems". CISA Research Note No. 15. Los Angeles: Center for International and Strategic Affairs (UCLA), June 1985.

4. **Summary:**

Kane argues that limited, specific agreements on testing of new strategic systems would be easier to negotiate than broad treaties and could be adequately verified. He applies this argument to testing in four areas: integrated testing, the Trident II missile, supersonic cruise missiles and anti-satellite systems.

Integrated testing involves the testing of several weapons systems simultaneously to integrate warning systems, communications and weapons systems for a potential nuclear exchange. A negotiated agreement could separate individual tests by reasonable time intervals. Kane suggests that an integrated test regime is "obviously highly visible and verifiable" (p.3).

The Trident II missile is expected to have a full counterforce capability and a lethality per reentry vehicle more than four times that of the Trident I. It can be launched in a low-trajectory orbit which would reduce the warning time to about 15 minutes. Testing restrictions could prohibit testing over short-ranges (less than 4,500 miles) so that the missile's counterforce capability could not be fully determined. Testing over flattened, non-ballistic trajectories could also be prohibited in order to decrease confidence in the accuracy achievable in the non-ballistic, short-time flight path. A prohibition of this sort was discussed in the SALT II negotiations. Kane comments that "both of these testing restrictions are easily monitored and verifiable; it is unlikely that such tests could be carried out undetected" (p.5). The military significance of a single undetected test would be minimal since a number of tests are needed to establish accuracy and reliability.

Second generation long-range supersonic cruise missiles would be destabilizing because of their low visibility and short flight time (less than an hour from Europe to Soviet command centers). Identification of the signatures of a supersonic long-range cruise missile such as its speed, fuel composition and engine temperature is possible with infra-red detection, precision radar and speed measuring devices so that "satisfactory verification is probable" (p.5). However, further study is necessary to demonstrate this convincingly.

A ban on the possession of ASATs would be difficult to negotiate, verify or enforce because the normal space activities of the superpowers involve equipment which could be used either as part of an ASAT system or as a part of a legitimate activity. However, testing limitations could control the development of ASATs and "verification of bans on specific ASAT testing procedures would be entirely satisfactory" (p.15). Three types of bans are possible.

(1) A ban on ASAT tests against objects in geosynchronous orbit (about 22,000 miles out). This would protect about two-thirds of all US satellites, including those with a strategic significance.

(2) A ban on testing infra-red homing devices on systems against any objects in space. This would inhibit ASAT effectiveness.

(3) A general ban on testing of any ASAT systems. This would be harder to negotiate than limited prohibitions and partial measures could prove to be just as effective as a total ban in terms of restricting ASAT deployment.

With a partial ban, there would still be a potential threat to US low-altitude satellites from the present Soviet ASAT, a modified Salyut resupply manoeuvrable vehicle or a ground-based laser. This poses no real threat to US national security and could be counteracted with countermeasures. Radiation detectors, impact detectors, manoeuvring capability and hardening against laser beams could reduce vulnerability and detect an ASAT attack if it occurred.

Verification of an ASAT test ban is possible with a variety of measures. American monitoring and space tracking capabilities are substantial. The NORAD Space Object Catalogue lists all space objects which are currently monitored. The Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system will enhance monitoring capabilities significantly starting around 1987. Improvements are being made in the ability to monitor objects in geosynchronous orbit. The United States can monitor Soviet satellites to see if they are under mock attack as part of an ASAT test. The technology exists to monitor the signatures of ASAT testing including those produced by the launch of the system, transmission of data from the ASAT and the satellite, visible damage to the target leading to non-standard motion or breakup, heating of the target and approach of one system near to another. Kane notes that "since all Soviet space objects and launches are monitored, a test only has a significant chance of going undetected if it is against an unoccupied point in space and if the attacking vehicle performs no manoeuvres to attract attention to it" (p.13). If the United States can construct a system under the Strategic Defence Initiative (SDI) to detect and track thousands of

launched objects simultaneously, then surely it can handle the tasks of verifying an ASAT test ban. Furthermore, Kane claims that "there is the possibility of detecting activity not only at the testing stage but at the stages of research and development, setting up and transporting the system, and deployment" (p.14).

In the case of ambiguous situations, a mechanism similar to the standing Consultative Commission established by SALT I (see abstract J67(T72)) could facilitate communication between parties to resolve concerns.

Proposal Abstract J66(A85)

1. **Arms Control Problem:**
Regional arms control - outer space - ASATs

2. **Verification Type:**
(a) Remote sensors - satellite
- ELINT
(b) Short-range sensors

3. **Source:**
Osborne, F.J.F. "The PAXSAT Concept: A Study of Space-to-Space Remote Sensing". In A Proxy for Trust: Views on the Verification Issue in Arms Control and Disarmament Negotiations, pp. 89-100. Edited by John O'Manique. The Norman Paterson School of International Affairs, Carleton University, Ottawa, Canada, April 1985.

4. **Summary:**
The Canadian PAXSAT feasibility study is discussed in this essay in terms of the system's proposed task, the nature of the political/international agreements which might govern its use, and the viability of a PAXSAT spacecraft in view of observational requirements and political restraints. The text is accompanied by a number of documents, graphs, charts, maps and design specifications. These provide additional information and help to clarify some of the more technical points.

PAXSAT is a space-to-space sensor system that is intended to verify an agreement banning weapons from outer space. It is designed to determine the function of unknown satellites with a reasonably high degree of confidence. A review of spacecraft configurations shows that it is possible to determine a craft's function by its external features. Communications to and from a spacecraft will also provide some indication of its purpose. "The nature of these transmissions, particularly the data rate, frequency band of operations, radiated power and the operational cycle are of extremely high diagnostic value" (p.90). PAXSAT would have technologies "which allow it to determine the basic parameters of all radiated emissions" (p.91). Finally, the orbit of a satellite will reveal its target and mission. All of these sources of information, when combined, give a good idea of a satellite's purpose.

With regard to agreements governing the use of PAXSAT, proposals for third party operation of the PAXSAT were rejected. An appropriate treaty would be negotiated by the superpowers, but would be multilateral in its application in order to avoid proliferation. Other nations might contribute data from their own national technical means of verification. It was decided that the technological limitations of PAXSAT were sufficient to regulate and help clarify its verificatory function. Its launch capabilities are limiting, and the

technology utilized in PAXSAT is such that it will contribute to stability. PAXSAT will also require a considerable amount of fuel for its operation, and this will effectively limit its capabilities. It will either be launched in order to co-orbit with a specific craft, or, alternatively, its orbit will intersect with other spacecraft. The latter fly-by method is less useful as it would not permit constant surveillance of a particular craft.

The PAXSAT spacecraft is conceived of a "roughly cubic propulsion module" which carries 3,000 kg of fuel and support sub-systems which are attached to 5 of its 6 sides. It possesses a high efficiency motor and 20 thrusters for fine positioning and manoeuvres. The software aboard PAXSAT is executed by a central computer "to provide the requisite spacecraft autonomy to protect both the PAXSAT and the target under observation" (p.93). The spacecraft also has a high-rate datalink which can relay information in real time or delay it by 15 minutes (employing a tape recorder) when ground stations are not visible. Finally, the technical specifications of PAXSAT are enumerated in graphs, charts, and diagrams at the end of the article. Its optical sensor has an aperture of 50 cm and a focal length of 60 m with a resolution of 100 cm at 100 km. Its approach and tracking capability has a frequency of 35 gigahertz, an antenna aperture of 1 m, an RF power of 20 watts and a range of 60 km. The PAXSAT has a range tracking accuracy of 4 m RMS and an angular tracking accuracy of 0.05 degrees.

Proposal Abstract J66.1(A85)

1. **Arms Control Problem:**
   Regional arms control - outer space - ASAT

2. **Verification Type:**
   Remote sensors - ground-based
   - radar
   - satellite

3. **Source:**
   United States. Congress. Office of Technology Assessment. Anti-Satellite Weapons, Countermeasures, and Arms Control. Washington, D.C.: US Government Printing Office, September 1985. OTA-ISC-281.

4. **Summary:**

Verification of compliance involves three distinct processes: monitoring, interpretation of the data obtained from monitoring and assessment of the risk which violations pose to national security.

Monitoring:

Existing and planned US capabilities are described. "Like the USSR, the United States can use missile attack warning radars and satellites to detect satellite launches and can track satellites after launched using ground-based and shipboard radar, LIDAR, passive radio sensors. The Space Detection and Tracking System (SPADATS) acquires, processes, stores, and transmits data from such sensors..." (p.55). The effective search range of ground-based radar is limited to low-earth orbit, although some radars can track a satellite at geosynchronous altitudes if its approximate position is known. For detection of satellites in deep space the US relies on telescopic electro-optical sensors of the Ground-based Electro-Optical Deep-Space Surveillance system (GEODSS) which can detect objects about the size of a soccer ball at geosynchronous orbits. (Charts and pictures of GEODSS equipment and facilities are included). In the future, surveillance of deep space could be performed both day and night, regardless of weather, by infra-red telescopes on satellites. Other existing capabilities such as those used to monitor the provisions of SALT agreements could also be used to monitor the construction and dismantling of launchers and facilities used for ASAT weapons. (The report includes Table 6.1 which summarizes sensor technology useful for monitoring compliance with various ASAT prohibitions.)

By investing in new monitoring systems and personnel, future monitoring capabilities can be made more comprehensive than existing capabilities" (p. 121). This will require years of work and substantial funds. Nevertheless, "some activities will always be

unmonitorable (eg. some forms of underground testing), other dual-purpose activities (eg. manned spaceflight) will often be difficult to characterize" (p.121).

Interpretation:

Monitoring data must be interpreted to determine the intent of an activity and how the activity relates to specific treaty provisions. The sophistication of the monitoring systems and prior experience regarding similar behaviour affect such determinations. Ambiguity of treaty language can play an important role.

Assessment:

Assessment of the risk posed to national security by a violation is based on at least three factors: (a) the threat posed, (b) the extent the treaty still contributes to national security, (c) the ability to take actions to prevent, mitigate, or compensate for damage caused by the violation. The result of this assessment will often determine the recourse to be pursued. Recourse can include withdrawal from the treaty, consultations, unilateral defensive countermeasures, research and development on treaty compliant offensive measures, negotiating modifications to the treaty, or matching cheating.

The report also reviews the verifiability of possible arms control undertakings related to ASATs.

Provisions Restricting ASAT Testing:

Among the problems associated with monitoring the wide range of Soviet activities possibly related to ASAT development is the enormous volume of space, ranging from 100 km altitude to 36,000 km, where illicit activities might occur. To some extent the volume of space which must be monitored is offset by the fact that space is transparent and accessible to monitoring. "Current weaknesses in ground-based e withdrawal from the treaty, consultations, unilateral defensive countermeasures, research and development surveillance systems can be mitigated by putting surveillance systems in space" (p. 108). In this regard, the report elsewhere mentions the development and operation of close-look inspection satellites equipped with gamma-ray spectrometers or other instruments capable of detecting materials used in nuclear explosives. Such satellites would help inhibit the deployment of nuclear space mines.

There is, in addition, a number of areas within the Soviet Union and its airspace which must be monitored. Fortunately, though large, this area is relatively well defined and "amenable to close inspection by space-based photographic reconnaissance satellites" (p.107).

Space-based ASAT activities must start on the ground. Relevant ground sites such as launch facilities can be observed by US sensors and launches can be detected. Development of air-based, ground-based or "pop-up" directed energy weapons would require extensive testing, some of which would be detectable.

The growing number and variety of Soviet space launches complicates verification. Experience with each type of satellite is required in order to classify its function and discriminate between unusual and routine behaviour. The functional characteristics of some ASATs such as space mines may not be readily observable. Fortunately, the number of new Soviet satellites engaged in unusual activities is

relatively small. Even if the US could not "by direct observation distinguish between space mines and normal satellites, other indicators, such as orbital parameters, proximity to other - particularly US - satellites, and other sources of intelligence might supply the needed information" (p. 108). The problem might be further resolved by inclusion of a mechanism for resolving ambiguities, such as the Standing Consultative Commission.

There are numerous ways for the USSR to covertly develop ASATs. But it is possible to exaggerate this threat. The development of any new system would require extensive testing, some part of which would be identifiable.

Provisions Restricting ASAT Possession or Deployment:

Even if the Soviet ASAT weapon is banned, its launchers, which are used for several non-ASAT roles, will remain available. Since the Soviet ASAT itself is small, it would be difficult for the US to verify that the Soviets do not retain a clandestine stockpile. In contrast, it would be easier for the Soviets to verify a ban on the US ASAT weapon currently under development. While small, the US ASAT requires large and distinctive support equipment. Moreover, expenditures on the system will be revealed in the annual authorization and appropriation process of Congress and in the press.

A limited possession ban permitting the retention of current ASATs would be easier to verify. Cheating in such a ban would involve testing of new systems which would be observable. Restriction on the number of deployed ASATs would be difficult to monitor in the absence of on-site inspection. The latter would not provide complete security since ASATs could be hidden and easily transferred to launch sites. Limits on the number of launch sites would be much easier to verify.

Provisions Restricting ASAT Use:

"Compliance with a "no-use" agreement would be relatively easy to monitor" (p. 115). This is particularly true for current ASATs. Development of an Soviet air-launched ASAT would complicate the task of the US because such an ASAT could be deployed outside the USSR. Covertly developed ground-based on air-based directed energy ASATs could be used to damage satellite sensors in such a way as to mimic a malfunction. On the other hand, effective on-board monitoring equipment could reduce this threat and in combination with a future space-based surveillance system, could verify a "no-use" agreement.

Provisions Restricting Spacecraft Operation and Orbits:

"The ability to monitor individual 'rules of the road' with high confidence would vary directly with the specific measures adopted "(p. 118). Generally, it would be easier than for other arms control regimes. The costs of failure to completely verify compliance would also be less.

Proposal Abstract J67(T72)

1. **Arms Control Problem:**
   Nuclear Weapons - anti-ballistic missile systems
   - ballistic missiles
   - manned bombers

2. **Verification Type:**
   (a) Remote sensors
   (b) Complaints procedure - consultative commission
   (c) Review conference (ABM Treaty)

3. **Source:**
   SALT I Agreements:
   (a) Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems. (The ABM Treaty).
   (b) Interim Agreement Between the United States of America and the Union of Soviet Socialist Republics on Certain Measures with Respect to the Limitations of Strategic Offensive Arms.
   Both signed: 26 May 1972,
   Both entered into force: 3 October 1972.*
   (c) Protocol to the Treaty Between the United States of America and the Union of Soviet Socialists Republics on the Limitation of Anti-Ballistic Missile Systems.
   Signed: 3 July 1972
   Entered into force 24 May 1976.
   See also: - United States. State Department. Bureau of Public Affairs. Compliance with SALT I Agreements, Special Report no. 55. Washington, D.C.: July 1979.

4. **Summary:**
   The ABM Treaty restricts deployment of ABM systems to two areas - one for defence of the national capital area and the other for defence of an ICBM site. The 1974 Protocol reduced these to a single site for each country. Limits are placed on the number of missiles and radar systems and on ABM research. Finally, testing of ABM systems is restricted to current or "additionally agreed" sites under the agreed interpretation of Article 4 included in the Protocol of the Treaty.

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* The Interim Agreement expired in October 1977. However both parties agreed to behave as if it remained in force. The ABM Treaty is of unlimited duration (Article XV).

Verification is to be accomplished by "national technical means" used "in a manner consistent with generally recognized principles of international law" (Article 12). Each party is obligated not to interfere with the other party's means of verification and not to use deliberate concealment measures. Complaints are to be referred to a Standing Consultative Commission (Article 13). Provision is also made for a review conference every five years (Article 15(2)).

The Interim Agreement provides for limits and restrictions on numbers and types of strategic nuclear weapons delivery vehicles. As under the ABM Treaty, verification is to be conducted by national technical means (Article 5, which is identical to Article 12 of the ABM Treaty). Complaints are to be referred to a Standing Consultative Commission (Article 6).

The Standing Consultative Commission was created by a Memorandum signed and entered into force on 31 December 1972. According to this agreement either party can request a meeting of the Commission at any time, though at least two meetings must be held each year. The scope of the Commission's functions were originally defined for the ABM Treaty (Article 12), but were later extended by the Memorandum of December 1972, to include other arms control agreements between the two superpowers.

The Parties can within the framework of the Commission:

(1) consider questions concerning compliance with the obligations under the various Treaties with which the Commission is concerned;
(2) provide on a voluntary basis such information as either party considers necessary to assure confidence in compliance;
(3) consider questions of unintended interference with national technical means of verification;
(4) consider possible changes in the strategic situation which have a bearing on the Treaties; and
(5) consider proposals on increasing the viability of the treaties and on further limiting of strategic arms.

On May 30, 1973 the Commission agreed on the regulations to govern its meetings. The following are the main points of these regulations:

(1) The chairmanship, of the meetings alternates between the parties.
(2) Advance notice of any topic of discussion is to be given when possible.
(3) Any expert adviser deemed necessary may participate in a meeting.
(4) The commission may establish working groups to deal with specific matters.
(5) The proceedings are to be conducted in private and neither party can make them public without the express consent of the other.
(6) Each party bears the expenses connected with its participation.

Text of Major Verification Related Provisions:

Article XII*

(1) For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical

* From the ABM Treaty.

means of verification at its disposal in a manner consistent with generally recognized principles of international law.

(2) Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.

(3) Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

Article XIII

(1) To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:
   (a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;
   (b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;
   (c) consider questions involving unintended interference with national technical means of verification;
   (d) consider possible changes in the strategic situation which have a bearing on the provisions of this Treaty;
   (e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this Treaty;
   (f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty; including proposals for amendments in accordance with the provisions of this Treaty;
   (g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.

(2) The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Standing Consultative Commission governing procedures, composition and other relevant matters.

5. **Selected Comments of States:**

The United States Department of State's report entitled Compliance with SALT I Agreements briefly describes the United States government organizational framework for verifying SALT I. It then lists the questions concerning compliance with both sides have raised in the Standing Consultative Commission to July 1979. It also responds to allegations of Soviet violations of SALT I, denying that they occurred.

The question of compliance has become very controversial since 1979. Abstracts dealing with this issue can be located via the Subject Index under the entry "compliance".

Proposal Abstract J68(A78)

1. **Arms Control Problem:**
   (a) Nuclear weapons - anti-ballistic missile systems
   - ballistic missiles
   - reentry vehicles

   (b) Conventional weapons - ground forces

2. **Verification Type:**
   Remote sensors - satellites

3. **Source:**
   Stockholm International Peace Research Institute. Outer Space: Battlefield of the Future. London: Taylor and Francis, 1978, pp. 184-185.

4. **Summary:**

Since ground resolutions of .15 metres for photoreconnaissance satellites are feasible there should be no difficulty in observing and identifying such objects as ABMs and ICBMs. It would be equally easy to use satellites to guard against significant concentrations of armed forces.

However, such control methods cannot be used to check qualitative changes in military systems although the development of certain new weapons can be detected at the testing stage. Even for quantitative verification, satellites are limited by the fact that for certain weapons, such as MIRVs, the identifying components are enclosed within the missile and hence undetectable.

For any verification by satellite an obligation not to use concealment for impeding verification is essential. This is incorporated into SALT I and should be applied to all other arms control treaties. The development of new sensors to penetrate some camouflage does not make this obligation of non-concealment any less important. Equally, a prohibition on interference with satellites is needed. The concept of verification by satellites could be jeopardized by developments such as satellite intercept and destroy systems.

Proposal Abstract J68.1(A85)

1. Arms Control Problem:
   (a) Nuclear weapons - anti-ballistic missiles
   - ballistic missiles
   - comprehensive test ban
   - cruise missiles
   - manned aircraft
   - missile tests
   - reentry vehicles
   (b) Regional arms control - outer space - ASATs
   (c) Any arms control agreement

2. Verification Type:
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Seismic sensors
   (d) Verification - general

3. Source:
   Scribner, Richard A., Theodore J. Ralston and William D. Metz. <u>The Verification Challenge: Problems and Promise of Strategic Nuclear Arms Control Verification</u>. Boston: Birkhauser, 1985.

4. Summary:*

The book is intended to assist concerned citizens in forming responsible opinions about the probable risks involved in arms control agreements by providing an introduction to the technologies and processes of verification and a discussion of what the US has learned from twenty years of verification and compliance experience. The main focus is on verification of stategic nuclear weapons agreement; other areas such as CWs are discussed only as they relate to this main focus. The information in this book is current to mid-1985.

Chapter Eight provides a brief summary of the key findings and observations of the book. Among these are the following:

(1) "Verification involves a complex set of technical, institutional, and political factors. There is no simple, universally accepted, definition of what constitutes adequate or effective verification. The judgement of adequacy is highly subjective" (p. 175).

(2) "The process of verification begins before a negotiation and continues as long as an agreement is in force. It involves monitoring and evaluation. Each nation's principle tool for

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* This book was received too late for a detailed summary to be prepared.

monitoring is its national technical means. In the future, NTMs could be augmented by various negotiated cooperative measures" (p.175).

(3) While the monitoring capabilities of NTMs are impressive, their coverage has limits. "However, verification of arms control agreements rarely, if ever, requires rapid response. NTMs are deployed in ways that are redundant, complementary, and synergistic, so that confidence in the detection capability of the overall technical network is enhanced" (p. 176).

(4) "While on-site inspection is not a panacea for verification and, in fact, would be informationally valuable in perhaps only a few kinds of agreements, its potential to operate if needed could have a deterrent benefit and substantially enhance mutual confidence. Some forms of on-site inspection make sense as part of the verification package for some kinds of arms control proposals such as nuclear test bans. For other kinds of agreements, where inspection would provide little additional verification information, insisting on such rights could be an unnecessary source of negotiating conflict" (p. 176).

(5) "Some risk is inherent in almost any approach to verification because information is usually incomplete. The level of uncertainty can be assessed and decisions made about the level of risk that is acceptable. It is important, however, not that verification be absolute but that it be adequate to maintain or enhance each party's security. In addition, the risks of non-compliance must be weighed against the risks of not having a treaty at all" (p. 180).

(6) "Certain safeguards or means of cross-checking the results of monitoring are in the verification process. These include the overall intelligence capabilities such as ongoing monitoring of new weapons development and cooperative measures agreed during the drafting of the treaty. Provisions for continuing consultations after a treaty is signed are an essential component of the overall verification and compliance process" (p. 181).

(7) "Not all activities that appear to be inconsistent with a treaty are necessarily violations, and not all violations are equally grave in their consequences. Many verification issues are ambiguous. The sources of the ambiguity include incomplete information, imprecise treaty language, and the implications of actions not forseen when a treaty was signed....Appropriate channels must be used for clarification of suspected violations....Raising a suspected arms control violation in public, rather than through established private channels, reduces the subsequent options for diplomatic solutions and political response....The extensive record of compliance questions raised privately in the SCC, as examined in Chapter five, shows that it is possible to resolve most issues in such a forum" (p. 181).

(8) "Questions will continue to arise about whether some particular approach to limiting a weapon system can be verified. However, when combined with carefully drafted arms control proposals,

including cooperation among countries to facilitate required monitoring, verification capabilities do not appear to be a limiting factor in achieving new and significant nuclear arms control and weapons reductions agreements" (p. 182).

Table of Contents:

J69(A61)

Proposal Abstract J69(A61)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles

2. **Verification Type:**
   Remote sensors - satellite
   - aerial

3. **Source:**
   Wiesner, J.B. "Inspection for Disarmament". In Arms Control: Issues for the Public, pp. 132-133. Edited by L. Henkin. Englewood Cliffs, New Jersey: Prentice-Hall, 1961.

4. **Summary:**
This proposal suggests that an agreement limiting the number of naval vessels that can be away from port at any given time would be an effective means of controlling the total size of the sea-based deterrent force. This, of course, presupposes an accurate initial count of vessels. Such an agreement could be monitored by national means, primarily by satellite and aerial surveillance.

Proposal Abstract J70(G62)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   United Kingdom. "Preliminary study of problems connected with the verification of the destruction of certain nuclear delivery vehicles". ENDC/54, 1 August 1962.

4. **Summary:**

It is envisaged that the process of destroying ballistic missiles would be carried out by the country owning the weapons and that the inspectorate would merely need to satisfy itself that the weapons scheduled for destruction had been destroyed. The proposal envisaged here seeks to satisfy this requirement and to preclude the possibility that a nation might replace weapons slated for destruction with substandard weapons. A certain way of ensuring that operational ballistic missiles are destroyed is to fire them on a range and check that they perform as expected and fall within some prescribed area. This would make divulging precise details of missile construction unnecessary. If the flights were pre-announced, the destruction process could be verified by non-intrusive national means.

Alternatively, it would be possible to establish "demolition factories" where certain missile components could be destroyed under international supervision. In this case, however, to ensure that the missiles schedule for destruction were not sub-standard, it might be necessary to establish "test centres" at which the highly specialized navigation and control equipment removed from the missile could be tested for accuracy and then destroyed or salvaged for civil use.

This latter system would require an inspectorate to be made up of technicians capable of carrying out the tests. The UK suggests that in the case of an inertially-guided missile, about 1 - 2 man weeks would be required to check the navigation system of the missile. Supervisors would also be required to monitor the destruction process, perhaps a dozen at each centre. Clerical staff might bring the total staff up to 100 per factory.

J71(A69)

Proposal Abstract J71(A69)

1. **Arms Control Problem:**
   (a) Nuclear weapons - ballistic missiles
   (b) Any arms control agreement

2. **Verification Type:**
   Remote sensors - satellite
   - ELINT

3. **Source:**
   Stone, Jeremy J. "Can the Communists Deceive Us?" In ABM: An Evaluation of the Decision to Deploy an Anti-Ballistic Missile System, pp. 193-198. Edited by Abram Chayes and Jerome Wiesner. New York: Harper and Row, 1969.

4. **Summary:**

The author evaluates American satellite surveillance capabilities and concludes that "the United States would have ample opportunity to observe and respond to Soviet efforts to shift the balance" (p. 198). Advances in satellite technology permit ground resolution on objects as small as one foot. Satellite reconnaissance can overcome camouflage with devices that use portions of the electromagnetic spectrum other than optical light (multispectral analysis). Clouds and darkness still create obstacles for observation, but satellites capable of manoeuvring and changing orbits to take advantage of breaks in the weather are being developed. Other satellites may be able to "swoop down" to as close as fifty miles above the earth to take close-up pictures. Surveillance devices other than cameras include radio receivers which can monitor Soviet radio transmissions.

Proposal Abstract J72(A73)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Greenwood, T. "Reconnaissance and Arms Control". Scientific American 288, no. 2 (February 1973): 14-25.

4. **Summary:**
   A series of satellite reconnaissance techniques provide a good deal of assurance that clandestine production of missiles could be detected. Area surveillance by observation satellites of objects such as transportation networks, power generation plants and manufacturing facilities could detect suspicious activities. Uncertainties raised in this way could then be investigated by high resolution photography, and by infra-red and multispectral sensor techniques. These last techniques are capable of providing a great deal of information about activities carried out inside buildings or under other coverings. Combined with observable changes in standard operating procedures, it is often possible to gain a good idea of important new developments.

J73(A76)

Proposal Abstract J73(A76)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Lodal, Jan M. "Verifying SALT". Foreign Affairs 24 (Fall 1976): 40-64.

4. **Summary:**

Lodal reviews charges that the Soviet Union has violated its obligations under SALT I and concludes that the evidence does not support the view that the USSR has cheated, that they are unreasonably pushing the limits of the agreements, that they are attempting to exploit "loopholes" or that US verification capabilities are inadequate.

Verification problems for SALT II will be greater than for SALT I. This is especially true of proposed MIRV limits. In the case of certain Soviet MIRVed missiles, monitoring the unique command, control and support facilities can permit verification of numerical limitations. In the case of other missiles a "typing" rule might be applied: if any missile is developed in both a MIRVed and unMIRVed mode, then all such missiles will be counted as MIRVed regardless of which version is deployed.

A less difficult but still significant problem of MIRV verification concerns distinguishing between two missile launchers (especially on submarines) which are identical except that one contains a MIRVed missile while the other does not. Employing a "typing" rule would be inconsistent with US deployment of Minutemen IIs and IIIs. Lodal suggests instead applying "typing" rules to classes of SLBMs and mobile ICBMs and also declaring which ICBM silos are unMIRVed.

Counting the number of strategic delivery vehicles generally will not pose problems except in the following instances. Mobile land-based ICBMs, especially if deliberate concealment is involved as in a "multiple aim point" system, will present verification difficulties. Lodal suggests agreeing to keep the numbers of such missiles low. Another problem will arise regarding distinguishing mobile IRBMs from mobile ICBMs. Lodal suggests agreement that any mobile launcher capable of launching an ICBM be "typed" as an ICBM. Finally, counting problems might arise for "bomber variants" such as

tanker and maritime patrol aircraft, the Backfire bomber and air-to-surface ballistic missiles (ALBMs). Lodal does not see these verification problems as serious, however.

Verifying limits on cruise missiles will be difficult. There are three likely problems here: determining the range of a particular missile, counting the number deployed and distinguishing nuclear and non-nuclear versions. To reduce these verification difficulties Lodal suggests that a single range limit apply to all types of cruise missiles (ALCMs, SLCMs, and GLCMs) and that above this limit all cruise missiles would be banned.

While verification of SALT II will not be certain, this must be balanced against other factors. First, no undetected Soviet cheating would make a significant difference strategically. The Soviets therefore would have little motivation to cheat. Finally, the value of SALT II outweights verification problems.

Lodal also discusses the ambiguous impact of technological improvements on verification. On the one hand, "national technical means" can be expected to become increasingly better. More frequent and reliable electronic and photographic data will be available. Combinations of methods will improve surveillance further. On the other hand, improved technology will permit easier evasion of NTMs. These improvements include encryption, shielding, decoying and spoofing.

Lodal also addresses verification of agreements on the reduction of strategic armaments. He feels that that US could easily verify such reductions in numbers but the lower force levels shrink, the more important verification will become since a small amount of cheating could make a significant different strategically.

Regarding qualitiative limitations on strategic arms such as accuracy of missiles, Lodal does not have much confidence in the verifiability of such agreements. On-site inspection, except of the most intrusive kind, would have little value.

Proposal Abstract J74(A79)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - satellites
   - aerial
   - shipboard
   - radar

3. **Source:**
   Aspin, Les. "The Verification of the SALT II Agreement". Scientific American 240, no. 2 (February 1979): 38-45.

4. **Summary:**

According to Aspin, verification is the keystone of any international arms control agreement. There are three levels of confidence concerning the ability of the US to detect violations of SALT II. First, there are numerous cheating methods for which the verification capabilities of the US are excellent, rendering the possibility of successful evasion by the USSR remote. This level of confidence applies to all the areas in which major violations of SALT II could upset the strategic balance. Second, there are several areas where the verification capabilities of the US are quite weak, but in all these cases cheating would not have militarily significant results. Third, there are a few areas where serious verification problems will arise at the next stage of SALT. This is the case for cruise missiles and transferable MIRV payloads.

Total launchers:

Regarding a ceiling on the total number of strategic launchers, there are three methods of evasion open to the USSR. The first is deployment of new types of strategic weapons. Building a new strategic weapon system involves at least five stages: research, development, testing, production and deployment. The US ability to detect clandestine activity during any of these phases ranges from fair to excellent. For the first phase alone the US has several ways of monitoring the USSR including: line-of-site and OTH radars, early warning satellites, and ship and aircraft based sensors.

The second evasion method is deploying additional weapons of existing types. Monitoring this is more difficult than for the first cheating method, but it is still very good particularly regarding production and deployment of missile carrying submarines and bombers.

For ICBMs, while construction of new silos and associated command-and-control systems can be detected, small-scale violations might be hard to identify primarily because of the time it takes to process satellite data.

The third cheating method is conversion of non-strategic weapons into strategic ones. There are substantial verification problems in this area. Regarding upgrading of the Backfire bomber into an intercontinental system, several aspects would be detectable including production, deployment, and training for in-flight refueling. The most difficult element is verifying the plane's characteristics, specifically its range and payload; cheating here could be undetected.

Regarding upgrading of the SS-20 (IRBM) into an SS-16 (ICBM) configuration, testing of the new system would be required which could be detected. Furthermore, testing of the SS-16 has been banned by SALT II.

Finally, regarding the possible reconfiguring into bombers of about 100 Soviet anti-submarine and reconnaissance aircraft, only a few would escape detection.

MIRVs and ALCMs:

There are also restrictions in SALT II placed on MIRVs and ALCMs for which there are four methods of evasion possible. The first is by constructing new silos and submarines for MIRVed vehicles. Such construction however could be readily detected. Second, MIRVed missiles might be substituted for unMIRVed ones in existing launchers. Verification in this case requires that the US know which Russian missiles are MIRVed and which launchers contain which missiles. To aid in this situation SALT II incorporates "typing" rules by which all missiles of a type that has been tested in a MIRVed mode or been fired from a launcher with a MIRVed warhead are counted as MIRVs. In addition, the US can detect which Russian silos and which Russian submarines contain MIRVed missiles because of their unique characteristics.

The third way of cheating is to replace the warhead on an unMIRVed missile with a MIRV payload. This would be very hard to detect but at present no such transferable warheads exist.

The fourth cheating method involves placing ALCMs on additional bombers. Presently, Russian cruise missiles must be externally mounted on bombers so the US can monitor their numbers. Modifications to aircraft to permit internal mounting would be detectable. For internally mounted ALCMs use of "typing" rules for ALCM capable bombers could be helpful. An additional problem concerns the range of the cruise missile. At present there is no systematic way of verifying the range of a cruise missile. Similarly, there is no way of distinguishing nuclear-armed cruise missiles from conventionally armed ones.

SALT II also prohibits "rapid reload" system. These can be verified by satellite since large equipment is needed for such a capability as well as extensive training.

Protocol:

The Protocol bans deployment and testing of mobile ICBMs. There is no question the US can detect deployment of such a system but determining the actual numbers could be difficult. The Protocol also prohibits testing and deployment of GLCMs and SLCMs with a range of more than 600 km. This is not verifiable. However, evasion here would present no threat before the Protocol expires.

In addition to the surveillance methods discussed above the US has other intelligence gathering methods including monitoring of internal communications and fortuitous sources such as defectors. The potential for violations is also reduced because of the degree of skill and luck demanded of the violator if he is to succeed in evading detection. Experience with SALT I has also demonstrated the powerful verification capabilities of the US.

It is questionable, as well, whether there would exist real motivation for the USSR to cheat. First, SALT II provides great scope for both sides to pursue strategic programs without cheating. Second, should the USSR become dissatisfied with SALT II it has other alternatives, such as renegotiating or withdrawing from the Treaty. Third, the USSR would face severe political repercussions if caught cheating.

In the first analysis, the real danger from violations of SALT II would arise only if there were a significant military advantage to be gained by cheating. But, even if the Russians successfully cheated in every way that might escape detection, they would add little to their strategic power and might even reduce their strength in some areas because of transfer of weapons systems from a regional mission to an intercontinental role.

Proposal Abstract J75(A79)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Short-range sensors - monitoring devices

3. **Source:**
   Garn, Jake. "The SALT II Verification Myth". Strategic Review (Summer 1979): 16-23.

4. **Summary:**

US ability to verify SALT II is limited to national technical means. There are major gaps in American NTMs resulting from loss of US facilities in Iran, betrayal of information on US reconnaissance satellites to Soviet agents, encryption of Soviet telemetry and budget cuts. There is some redundancy in US capabilities but the loss of a single system can leave a gap.

The US government has failed to respond to extensive Soviet violations of SALT I which is essential to the success of the deterrence role verification. Given these past violations Garn contends that the US can not expect Soviet cooperation regarding verification of SALT II. SALT II will legitimize Soviet encryption of telemetry and the US will be unable to distinguish legitimate from illegitimate encryption.

The qualitative restrictions of SALT II such as those on throw-weight and missile size cannot be adequately verified. There is therefore a potential for Soviet clandestine missile deployment. Nor can the capabilities of bombers and the range of cruise missiles be monitored.

Garn recommends as a minimum step that the US seek to enhance the status and powers of the Standing Consultative Commission to enable it to implement cooperative US-USSR verification measures including a provision allowing for "no-notice" on-site inspection. Moreover each nation could agree to the installation on its territory of several monitoring sites operated by the other nation.

Proposal Abstract J76(A79)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - missile tests

2. **Verification Type:**
   Remote sensors - satellite
   - aerial
   - radar
   - shipboard

3. **Source:**
   Mencrist, Frank. "SALT Verification: How We Monitor the Soviet Arsenal". Microwaves (September, 1979): 41-51.

4. **Summary:**

Much information on Soviet missile tests is gathered from receivers and radars which 'eavesdrop' on the telemetry data transmitted during missile tests. Telemetry relays information on the design details of Soviet ICBMs, and provides an 'electronic window' on the missile itself by transmitting data on the operation and functions of the missile's subsystems. The importance of telemetry interceptions is such that interference with this means of verification is forbidden under SALT II.

One central component of the verification network in telemetry interception are the Rhyolite satellites. These are high altitude geosynchronous satellites which use infra-red detectors to detect missile booster exhaust fumes. They are able to operate at night but cannot penetrate cloud cover, and otherwise have continuous line of sight access to the main Soviet test ranges. As stationary satellites, Rhyolites may observe continually, but their effectiveness may be degraded by a reduction in transmitter power. Consequently, the US has begun to rely more on lower orbit satellites such as the Ferret, which cannot be countered so easily; these satellites are closer to the sites under observation, yet are still sufficiently removed to be immune from international unrest. As such, they are more invulnerable than the high flying aircraft which patrol the borders of the Soviet Union in Turkey and Pakistan. The latter may assist in telemetry interception as well, but their sensitivity is limited by the number of antennae that a plane can carry.

Radar also complements telemetry interception by providing data on "missile trajectory, velocity, range, manoeuvrability and the number of reentry vehicles" (p.49). The information it provides pertains more to the movement and capabilities of a missile rather than its electronic make-up. Radar is generally limited by line-of-sight restrictions and can only monitor high altitude tests at

greater distances. Over-the-horizon (OTH) radar may overcome these limitations to some extent, as it uses the earth's ionosphere to reflect radar waves. The actual capabilities and uses of OTH radar are unknown, but it is surmised that it is currently in operation, given that the US has had the requisite technology for 18 years. It is probable that there is a ground-based OTH radar on Cyprus, and the ship-based, phased array 'Cobra Judy' radar may also have an OTH capability. Finally, a space-based radar is currently being developed by the United States which would assist in monitoring missile tests. Lower orbit radars would permit 'close looks', while a geostationary satellite radar station could be placed over test ranges to monitor the launch and trajectory of airborne missiles.

Proposal Abstract J77(A79)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned bombers
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Milburn, Thomas W. and Kenneth H. Watman, "SALT II: Verification". Mershon Centre Quarterly Report 4, no. 4 (Summer 1979).

4. **Summary:**
This paper, based on open sources, reviews American verification capabilities and their use for monitoring SALT II. Four verification "principles" are identified:
(1) verification is a substitute for trust,
(2) adequacy,
(3) relevance, and
(4) the standard of evidence is less than beyond reasonable doubt.

Sensor technology is then reviewed and its utility for SALT including:
(1) x-ray and gamma ray detectors (not useful),
(2) ultra violet detectors (some value for missile launches),
(3) visible spectrum detectors (highly useful),
(4) infra-red detectors (highly useful)
(5) radar (highly useful), and
(6) radio frequency detectors (highly useful).

US observation satellites and missile test surveillance capabilities are examined. Finally, the verification of specific SALT II provisions is assessed. While this paper provides little original information, it is a useful summary of several other articles in the open literature.

Proposal Abstract J78(A79)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - missile tests

2. **Verification Type:**
   Remote sensors - satellites
   - radar
   - ground-based

3. **Source:**
   Pioro, Tadeusz. "Military Commentator Views SALT Verification Methods". Warsaw Slowo Powszechne (in Polish) 18 July 1979 p.2. Translation: Joint Publications Research Service document #74037, pp. 26-28.

4. **Summary:**

   The author comments mainly on American verification capabilities, but makes passing reference to Soviet capabilities. He concludes that "the currently available system of verification still gives no guarantee of detecting all cases of violations but, taken as a whole, it is sufficient to guarantee that any undetected violations would not be big enough to have military significance" (p. 27).

   There has been considerable progress in the design of super wide-angle lenses which cover major portions of the Earth. Automatic self-adjusting cameras can perform well under existing atmospheric conditions and film processing techniques permit on-board processing in satellites. Modern cameras and film have high light sensitivity and "exceptionally high" (p.27) resolution. Near real-time reconnaissance is possible. Powerful ground radar stations can permit surveillance at a distance of about 5,000 kilometres. Orbiting radars with an unlimited horizon are currently being considered and will likely be deployed. There are many opportunities for observing the flight results of ICBM tests, but determining the operational readiness level of ICBMs and the number of warheads with which they are armed is difficult.

   An American system called Seaguard is being developed to detect submarines. It will use fixed and mobile sensing systems to pick up the cavitation noises emitted by submarines during their movement. The author comments that "there can be no doubt that a similar system is being developed in the Soviet Union" (p.28).

Proposal Abstract J79(T79)

1. **Arms Control Problem:**
Nuclear weapons - ballistic missiles
- cruise missiles
- manned aircraft
- missile tests
- mobile ballistic missiles
- reentry vehicles

2. **Verification Type:**
(a) Remote sensors - aerial
- ground-based
- satellite
- shipboard

(b) Complaints procedure - consultative commission
(c) International exchange of information

3. **Source:**
(a) Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms (to be in force until 31 December 1985).
(b) Protocol (to be in force until 31 December 1981).
(c) Ancillary Agreed Statements and Common Understandings.
(d) Joint Statement of Principles and Basic Guidelines for Subsequent Negotiations on the Limitation of Strategic Arms.
(SALT II).

Signed 18 June 1979. Not ratified by the United States.*
See also: - United States. Department of State. Bureau of Public Affairs. Verification of the SALT II Agreement. Special Report #56. Washington, D.C.; August 1979.

4. **Summary:**

SALT II involves a complicated framework of restrictions on several strategic nuclear weapons delivery systems. The principal methods of verification specified are "national technical means" (Article 15(1)) which are to be used in accordance with generally recognized principles of international law. In a glossary developed by the United States, NTMs are defined as "assets which are under national control for monitoring compliance with the provisions of an

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* On 27 May 1986 President Reagan announced that the US would no longer be bound by some of the limits on strategic weapons included in the SALT II Treaty. In late November 1986 the US deployed its 131st reconfigured B-52 capable of carrying ALCMs, thereby exceeding limits under SALT II.

agreement. NTMs include photographic reconnaissance satellites, aircraft-based systems (such as radars and optical systems) as well as sea-and ground-based systems such as radars and antennas for collecting telemetry". Each party also undertakes not to interfere with the NTMs of the other (Article 15(2)) and not to use deliberate concealment measures to impede verification by NTMs (Article 15(3)).

The foregoing provisions are similar to those of the SALT I Interim Agreement (Article V) and the ABM Treaty (Article XII) (see abstract J67(T62)). In contrast to SALT I, however, the superpowers have agreed to more precise definitions of concealment and incorporated these into the SALT II framework in the form of Agreed Statements and Common Understandings. These include the following:

(1) The ban on concealment applies to testing, including the concealment of the association between ICBMs and launchers during testing.
(2) The ban also extends to methods of concealing transmission of telemetric information during testing including encryption when it impedes verification of the Treaty. Encryption is defined in the American Glossary as coding communications for the purpose of concealing information.
(3) The ban includes shelters over ICBM silo launchers that impede verification.

The careful definition of the weapons systems and activities subject to restriction under SALT II has also been dictated by the requirements of verification using NTMs. In particular, mention should be made of "Functionally Related Observable Differences" (FRODs) and "Observable Differences" (ODs) which are criteria established for distinguishing between those weapons systems which are capable of performing functions banned under SALT II and those systems which are not.

Also relevant to verification are the counting rules incorporated into SALT II whereby the parties agree that once a weapon system has demonstrated a capacity to be used in a certain configuration (such as in a MIRVed mode), then it will be assumed for purposes of counting that all the individual missiles or launchers of that system are in that configuration (i.e. all are MIRVed). In other words, it is not necessary to try to distinguish between different variations of the same missile (such as one which is MIRVed and one which is not) which would complicate verification considerably.

Salt II also incorporates collateral constraints which are intended to assist verification. For example, a ban is placed on the production, testing and deployment of the SS-16 ICBM because its similarity with the SS-20 IRBM might have caused verification problems.

The SALT II Agreement also provides for the continued use of the Standing Consultative Commission established in a Memorandum of Understanding of December 1972 as a follow-on measure to the SALT I Treaties. The Commission's functions are somewhat expanded, however, to make the body into a forum for the following:

(1) Agreement on procedures for replacing, converting, dismantling or destroying strategic arms in cases provided for in the provisions

of SALT II and on procedures for removal of such arms from the aggregate number when they otherwise cease to be subject to the limitations specified in SALT II. At regular sessions of the Commission parties are to notify each other in accordance with the aforementioned procedures, at least twice annually, of actions completed and those in progress (Article 17(2e)),

(2) Consideration of proposals for further measures limiting strategic offensive arms (Article 17(2g)).

Also, under Article 17(3) the Commission is given the responsibility for maintaining an agreed data base on numbers of strategic offensive arms established as part of SALT II by a Memorandum of Understanding of 18 June 1979. In an Agreed Statement the Parties specify that the data base is to be updated at each regular session of the Commission through the notification by each Party of any changes to the categories establishment by SALT II. As part of the SALT II package both sides provided "Statements of Data on the numbers of Strategic Offensive Arms as of the Date of Signature of the Treaty", which are to constitute the basis of the aforementioned data base.

Other forms of information exchange are also incorporated into the Treaty to assist verification. These take the form of prior notifications of events, usually through the Consultative Commission. Among these are the following provisions for notification:

(1) Future types of heavy bombers (Article 2(3) and the Second Agreed Statement).
(2) New types of MIRVed SLBMs when first installed on a submarine (Article 2(5) and the Second Agreed Statement).
(3) Plans to flight test unarmed pilotless guided vehicles with a range greater than 600 km. (Article 2(8) and the Fifth Common Understanding).
(4) The first and last test launches of the new type of ICBM which each party is permitted to develop (Article 4(9) and the Second Agreed Statement).
(5) The number of ALCM test planes (Article 7(1) and the Second Common Understanding).
(6) New ICBM test ranges (Article 7(2) and the Second Agreed Statement).
(7) ICBM test launches which extend beyond the territory of the party and all multiple test launches of ICBMs (Article 16(1)).

Such notifications presumably will allow the other party to concentrate its NTMs on the activity.

Finally, in the 'Joint Statement of Principles and Basic Guidelines for Subsequent Negotiations on the Limitation of Strategic Arms' both sides have agreed that further limitations and reductions must be subject to adequate verification by NTMs using also, as appropriate, cooperative measures contributing to the effectiveness of verification by these means. The parties are also committed to strengthening verification and perfecting the Standing Consultative Commission.

Text of Major Verification Related Provisions:

Article XV

(1) For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

(2) Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with with paragraph 1 of this Article.

(3) Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

To Paragraph 3 of Article XV of the Treaty:

First Agreed Statement. Deliberate concealment measures, as referred to in paragraph 3 of Article XV of the Treaty, are measures carried out deliberately to hinder or deliberately to impede verification by national technical means of compliance with the provisions of the Treaty.

Second Agreed Statement. The obligation not to use deliberate concealment measures, provided for in paragraph 3 of Article XV of the Treaty, does not preclude the testing of anti-missile defence penetration aids.

First Common Understanding. The provisions of paragraph 3 of Article XV of the Treaty and the First Agreed Statement thereto apply to all provisions of the Treaty, including provisions associated with testing. In this connection, the obligation not to use deliberate concealment measures includes the obligation not to use deliberate concealment measures associated with testing, including those measures aimed at concealing the association between ICBMs and launchers during testing.

Second Common Understanding. Each party is free to use various methods of transmitting telemetric information during testing, including its encryption, except that, in accordance with the provisions of paragraph 3 of Article XV of the Treaty, neither Party shall engage in deliberate denial of telemetric information, such as through the use of telemetry encryption, whenever such denial impedes verification of compliance with the provisions of the Treaty.

Third Common Understanding. In addition to the obligations provided for in paragraph 3 of Article XV of the Treaty, no shelters which impede verification by national technical means of compliance with the provisions of the Treaty shall be used over ICBM silo launchers.

5. **Selected Comments of States:**

The US government addresses the verification of SALT II in a 1979 US State Department publication entitled Verification of the SALT II Agreement. This document states the criteria which the US employs to determine adequacy of verification as the following:

(1) the capabilities of existing and projected intelligence collection systems and analysis techniques,
(2) the measures the Soviets could take to evade detection,
(3) the costs and risks to the Soviets of any attempt to evade the limits,
(4) the military significance of potential violations,
(5) the capability of the US to offset the effects of potential Soviet non-compliance and carry out appropriate and timely responses if violations are discovered, and
(6) tradeoffs of verification considerations in order to allow US flexibility in its own weapons programs.

The paper concludes that the US government is confident of its ability to adequately verify the agreements.

The question of compliance has become more contentious since 1979. Abstracts dealing with this issue can be located via the Subject Index through the entry "compliance".

Proposal Abstract J80(A80)

1. **Arms Control Problem:**
   Nuclear weapons: - ballistic missiles
   - missile tests
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - ground-based
   - satellite

3. **Source:**
   Aspin, Les, and Fred M. Kaplan. "Verification in Perspective". In <u>Verification and SALT: The Challenge of Strategic Deception</u>, pp. 177-190. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**
The authors address themselves to four areas of concern regarding verification of SALT II. First, can restrictions on missile launch-weight and throw-weight by verified? They conclude than even without Iranian listening posts the US can keep tract of significant changes in Soviet missile fuel type, throw-weight and, to a lesser extent, launch-weight. The Soviets, clearly, might be able to make modest changes in throw-weight beyond SALT limits without US detection but if they tried to exploit this additional weight in any militarily meaningful manner their efforts would almost certainly be discovered. In addition to this lack of incentive for the Soviets to cheat, the uncertainties involved in verification of this provision create fewer and smaller risks than would exist for the US without SALT II.

The second verification problem discussed is telemetry encryption. SALT II includes provisions against encryption which impedes verification. In the event of encryption of any data, it would be possible to determine whether the information being hidden was important for verification. Other cheating strategies are examined by the authors and they conclude that they are not very serious threats. Also, SALT II requires that the Soviets make available far more data than they would otherwise.

The third verification question is whether the US can verify the number of warheads on heavy missiles particularly the SS-18 which has apparently been tested to release 12 reentry vehicles instead of the 10 which would be permitted under SALT II. The authors contend that the number of tests so far is insufficient for operational deployment of this configuration of the SS-18. In addition, even assuming the SS-18 can carry 12 warheads this is preferable to the 25 possible without SALT II.

Finally, the authors address themselves to the possibility of the Soviets covertly stockpiling ICBMs. There are a number of difficulties with this scenario according to Aspin and Kaplan. They conclude that the uncertainties involved with respect to missile stockpiling under SALT II create fewer and less serious risks than those the US would face without the Treaty.

Proposal Abstract J81(A80)

1. **Arms Control Problem:**
   (a) Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

   (b) Regional arms control - outer space - ASATs

2. **Verification Type:**
   (a) Remote sensors - aerial
   - ELINT
   - ground-based
   - radar
   - satellite
   - shipboard

3. **Source:**
   Blair, Bruce G. and Garry D. Brewer. "Verifying SALT Agreements". In Verification and SALT: The Challenge of Strategic Deception, pp. 7-48. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**

This is a very thorough and comprehensive review, based on unclassified sources, of current technical means of verification available to the US for monitoring SALT agreements.

The authors include in their review a brief history of Soviet-US verification experience since the Second World War. They claim that this history supports the view that verification is the key to the success of SALT.

After a brief summarization of the provisions of the SALT II Treaty, the authors discuss several assumptions that have a bearing on the issue of verification. For example, they point out that:

(1) flight testing new ballistic missile systems seems likely to be a part of the development of that system,
(2) the sensitivity of satellite sensors are expected to vastly improve over the next 20 years,
(3) strategic weapons need not be kept under continuous surveillance to assure compliance with SALT,
(4) verification is not simply a technical question; judgement, analysis and inference all weigh heavily in the process, and
(5) reliance on multiple monitoring systems will continue to play a major role in SALT verification.

A highly detailed review of current American verification capabilities follows. First, satellite platforms and sensors are examined. The authors claim that the resolution of "close look" satellite photography is now in the order of three or four inches which is probably the limit allowed by the atmospheric scattering of light caused by turbulence and pollution. They also present tables indicating the target resolution required for the verification of different weapons system. Also discussed are the limitation on satellite sensors including cloud cover, darkness, time over the target, timeliness of data, and camouflage. Their discussion covers satellites other than photographic reconnaissance ones as well as a variety of sensor systems.

Next, the authors consider data transmission and analysis. They point out the need to use computers in analyzing the data obtained from sensors and the concern which has arisen about the lag between the capability to generate data and the capability to analyze it in a timely fashion.

American ground sites are then examined, particularly radar and electronic listening stations used to monitor Soviet missile testing. This discussion includes an assessment of the impact of the loss of Iranian-based posts. They conclude that US ground sites can still monitor Soviet compliance with flight test restrictions with a high-degree of success. However, while the US will continue to be able to monitor Soviet flight tests during reentry and splashdown, its ability to monitor telemetry and other characteristics during the early stages of tests appears to be "borderline for verification purposes" (p. 33).

The role of aircraft and ships in US verification capabilities is next reviewed. Both play important roles. The US ability to monitor anti-satellite testing agreements is then examined. The focus here is on the North American Air Defense Command's space tracking system. Again the discussion includes consideration of present capabilities and future developments.

In addition to the above methods, the authors also discuss briefly other means of obtaining verification information. They mention "ferret" electronic intelligence satellites, reconnaissance submarines and sophisticated sensors hidden inside the territory of potential adversaries or on the adjacent sea floor. These sources of intelligence, the authors feel, may not be legal and, thus, remain outside the provision in the SALT agreements preventing interference with national technical means which are used in a manner consistent with international law.

While technical information is more reliable generally than non-technical information, as new arms control agreements become harder to verify using technical means, the value of espionage and other covert activities may have to be reconsidered. While the US should not rely on these methods, they should not be dismissed out of hand.

Finally, the authors point out the role of the Standing Consultative Commission. The intent of this body is that both sides are committed to providing clarifying information to the queries of the other.

Blair and Brewer also include at the end of their paper an assessment of US capabilities for monitoring controls on anti-satellite warfare activities, controls which they claim deserve high priority. US satellite surveillance is good up to 3000 miles and activities in deeper space can be monitored fairly well today. Within ten years new ground and space-based sensors will permit reliable monitoring of a variety of anti-satellite activities.

 J82(A80)

Proposal Abstract J82(A80)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Cohen, Stuart A. "The Evolution of Soviet Views on SALT Verification: Implications for the Future". In Verification and SALT: The Challenge of Strategic Deception, pp. 49-75. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**

   The author reviews Soviet public commentary on the issue of SALT verification in an attempt to establish the views of the Soviet government. Several observations about Soviet views are made including:

   (1) Initially all satellite reconnaissance was considered illegal by the Soviet government.
   (2) Presently at least some satellite and ground-based reconnaissance is considered legal.
   (3) Some forms of non-reconnaissance satellite-borne activity are today considered illegal.
   (4) A Soviet controlling organization and a weapons development program for interference with satellites exist.
   (5) Some forms of camouflage, concealment and deception in the context of strategic weapons are not perceived to be prohibited by existing arms control agreements.
   (6) It is difficult to determine how the Soviet distinction between legitimate and illegitimate reconnaissance and between licit and illicit camouflage can be operationalized.
   (7) Despite movement on the issue it is wrong to suggest that blanket approval of US reconnaissance activities has occurred.

Proposal Abstract J83(A80)

1. **Arms Control Problem:**
Nuclear weapons - ballistic missiles
- cruise missiles
- manned aircraft
- missile tests
- mobile ballistic missiles
- reentry vehicles

2. **Verification Type:**
Remote sensors

3. **Source:**
Humphrey, Gordon J. "Analysis and Compliance Enforcement in SALT Verification". In Verification and SALT: The Challenge of Strategic Deception, pp 111-127. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**
The author contends that US faces three verification problems: declining intelligence collection capabilities in the face of more challenging monitoring requirements, faulty analysis, and declining US will to challenge Soviet activities and enforce Soviet compliance. He claims that the "compromising" of two American satellite collection systems by Soviet espionage, the loss of Iranian-based listening posts and budget restraints have resulted in a cutback in technical collection capabilities. He reviews Soviet compliance with the SALT I Accords contending that the Soviets were guilty of several violations and claiming that both evidence and analyses of these have been suppressed by the US government.

J84(A80)

Proposal Abstract J84(A80)

1. **Arms Control Problem:**
 Nuclear weapons - ballistic missiles
 - cruise missiles
 - manned aircraft
 - missiles tests
 - mobile ballistic missiles
 - reentry vehicles

2. **Verification Type:**
 Remote sensors

3. **Source:**
 Katz, Amrom H. "The Fabric of Verification: The Warp and the Woof". In Verification and SALT: The Challenge of Strategic Deception, pp. 193-220. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.
 See also: - Verification and SALT: The State of the Art and the Art of the State. Washington, D.C.: Heritage Foundation, 1979.

4. **Summary:**
Katz contends that US intelligence services and the Soviet Union have existed in a symbiotic relationship. To be effective for deterrence, a weapons system must be known to the other side. The Soviets have used US intelligence as a route for disclosing their capabilities. They have done this by not being excessively "non-cooperative". The question therefore remains, according to Katz, as to how good is US intelligence if the Soviets are motivated to cheat. He reviews several reasons why they would and several methods by which they could cheat. He concludes that the capability of US intelligence to monitor covert deployments is uncertain and calls for a review of US abilities in this regard by an interagency group not involved in the SALT negotiations.

Proposal Abstract J85(A80)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   (a) Remote sensors - aerial
   - ground-based
   - satellite
   - shipboard
   - ELINT
   - radar

   (b) Complaints procedure - consultative commission

3. **Source:**
   Kincade, William H. "Verification and SALT II". In <u>SALT II and American Security</u>, pp. 28-52. Cambridge, Mass.: Institute for Foreign Policy Analysis, 1980.

4. **Summary:**
   This article examines the verification requirements for monitoring the SALT II Treaty (see abstract J79(T79)) and American capabilities to fulfill those requirements. Kincade concludes that "when verification is viewed in terms of what it needs to do to assure American security... it becomes increasingly difficult, if not impossible to see what violations the Soviet Union could commit that would (a) add significantly to Soviet strategic capability and (b) escape ready detection by American reconnaissance and monitoring facilities" (p. 41). Even an additional 250 ballistic missile launchers above SALT II limits would not add to the "hypothetical threat" to the US Minuteman force, and deployments of this or lesser magnitude would be "highly and quickly visible to US sensors" (p.42). Development of a new Soviet intercontinental bomber would be detected because of signs associated with producing a type of aircraft not built in the Soviet Union for many years. Equipping such aircraft with long-range cruise missiles would require extensive tests which could be detected and observed. Difficulties in detecting the conversion of medium-range bombers to intercontinental range would be insignificant because this development would add nothing to the Soviet first-strike capability. Even observing changes in existing missile dimensions to SALT II specifications, though difficult, will not be impossible with repeated measurements over time.

The adequacy of verification capabilities depends on the importance of the item to be verified. Confidence in verification should be sufficient to detect militarily significant violations, but detection of smaller violations is important too because it provides early warning and generates confidence that violation of crucial provisions could also be detected. For SALT II, verification requirements include "treaty provisions so crafted that, to the extent possible, even if a deliberate violation occurred, it would not materially or immediately affect the balance of forces or the security of either party" (p.30).

Kincade reviews the technology and methodology of verification available to the United States. Table 1 (p.42) outlines US verification techniques, observation areas in the USSR and the source location of American observation for the various items covered under the 1972 ABM Treaty (see abstract J67(T72)) and the SALT II agreements. Imaging sensors can provide "highly reliable data on Soviet weapons deployment, testing and associated activity" (p.37). Objects as small as six inches can be detected. Infra-red and multispectral scanners can penetrate cloud cover, nighttime darkness and camouflage as well as detect underground silos and help identify missile types through observation of different exhaust fumes in tests. The Big Bird satellite can perform both area surveillance and close look missions and has an ability to retrieve and process data more quickly than older satellites. The new KH-11 satellites "possess even better surveillance capacity" (p. 38). Advanced vidicon beam and other video systems can permit near real-time collection of image data which is useful for observing changes in ground activities. Electronic image enhancement techniques can also assist monitoring activities included in SALT II.

ELINT or more specifically RADINT (radar intelligence) radars can be used for monitoring Soviet missile tests. The United States has collected unencrypted Soviet missile telemetry for years. With this data and knowledge acquired from its own missile tests, the US is able to determine which performance data should not be encrypted as provided for by SALT II verification provisions. Kincade disagrees with those who argue that the Treaty should prohibit all encryption of telemetry for the following reasons: (1) the US possesses the technical ability to discriminate between missile performance data which is relevant to compliance with SALT II and that which is not; (2) the United States may in the future wish to encrypt some of its own telemetry; (3) performance data can be safeguarded by methods other than encryption; and (4) it is technically possible to transmit telemetry which would provide false but unencrypted information to the United States and accurate performance data to Soviet technicians. Raising objections about false telemetry in the Standing Consultative Commission would require proof which would reveal American cryptographic techniques.

American radio monitoring of Soviet communications could intercept information about forthcoming missile test activities which do not require notification under SALT II. Information and telemetry

can be collected by radars at ground stations located at both ends of the Soviet ICBM test ranges, ships in the Pacific Ocean, satellites (though not as well as ground stations) and shipboard systems in the Barents Sea. The closure of ground stations in Iran has not inhibited monitoring capabilities because information on ballistic missile tests can still be obtained from satellites and collection facilities in the Aleutian Islands or the Pacific Ocean.

Despite offering an optimistic assessment, Kincade does point to future verification problems. Verifying indices of weapon lethality such as warhead yield-to-weight ratios and guidance systems (accuracy) is not possible at present and will likely remain impossible. There are also problems with verifying dual-mission (theater or strategic) and dual-capable (conventional or nuclear) systems as well as missiles in a deceptive basing mode (possibly the MX missile) and sea- and ground-launched cruise missiles.

Proposal Abstract J86(A80)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Kruzel, Joseph J. "Verification and SALT II". In Verification and SALT: The Challenge of Strategic Deception, pp. 95-110. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**

The author distinguishes between "monitoring" (i.e. "using intelligence capabilities to find out what the other side is or is not doing, first by collecting and then by evaluating new intelligence" (p.96)) and "verification" (i.e. "determining the adequacy of a nation's capability to monitor compliance" (p.96)). To monitor SALT II the US will use NTMs. It appears to have abandoned its long attachment to on-site inspection which would be of little benefit in monitoring most provisions of the Treaty. NTMs will also avoid the complexities of an on-site system because they can be unilaterally deployed and controlled, they are unobtrusive, and the data they provide are accessible and reliable.

The essence of monitoring is determining some level of confidence in detecting a violation. The author presents the US views on what this level should be. Also included is a discussion of the impact of the loss of Iranian-based monitoring facilities.

Concerning "verification" the author discusses Soviet incentives to violate the Treaty and the possibilities of covert deployment of strategic weapons by them. He also emphasizes the importance of reaction to suspected violations. The author concludes that the SALT II verification meets the standard of "adequate verification".

 J87(A80)

Proposal Abstract J87(A80)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Perle, Richard N. "What is Adequate Verification?" In SALT II and American Security, pp. 53-65. Cambridge, Mass.: Institute for Foreign Policy Analysis, 1980.

4. **Summary:**

Perle specifies two conditions which are necessary for treaty verification: precision in drafting so that the parties agree on what would constitute a violation and the technical ability to collect information necessary to verify non-compliance. He finds the SALT II Treaty lacking in both respects and faults the Carter Administration for these defects.

Imprecision is prevalent in the language of the Treaty. Key terms such as "launcher" and "deployed" are not defined and there is no agreement on characteristics of the Soviet Backfire bomber. This inhibits a distinction between "current" heavy bombers and "future" bombers.

The ability to utilize collected information to demonstrate non-compliance is inhibited because disclosure of information in many cases would reveal the nature of American sources. In addition, some collection systems will likely be lost which will reduce verification capabilities. The loss of ground stations in Iran is an example of such possible occurrences. National technical means of verification, too, may not be dependable because, even though the Treaty provides for such verification in accordance with international law, it is not clear exactly what forms of intelligence collection are permitted by international law. There is also no common understanding of what constitute NTMs. The Soviets object to the inclusion of intelligence agents and listening posts in third countries under this classification. Interpretation of Article XV of the Treaty suggests that interference with NTMs would have to be deliberate to constitute a violation of Article XV. Intent in this case is difficult to prove. Without on-site inspection, "the range of possible arms control agreements that will be verifiable is likely to be very narrowly constrained" (p. 62).

Verification is further hampered by Treaty provisions on the encryption of telemetry. The Treaty allows the Soviets to be the "final arbiters" of what telemetry data are necessary for verifying compliance. Furthermore, this cannot be effectively challenged; the US cannot discern the nature of the data. The Soviets could also prevent telemetry interception by recording flight test data on board the vehicle and dropping the data package to earth. This would not necessarily be a violation of the Treaty. Transmitting telemetry at low power levels is another possible method to evade interception.

Proposal Abstract J88(A80)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - ELINT
   - ground-based
   - radar
   - satellites
   - shipboard

3. **Source:**
   Stockholm International Peace Research Institute. World Armaments and Disarmament Yearbook: 1980. London: Taylor & Francis, 1980, pp. 293-312.

4. **Summary:**

This chapter from the SIPRI Yearbook evaluates the verification system intended for SALT II. Respecting qualitative data about weapons systems, it points out that the major activity to be verified is flight testing of ballistic missiles since this is the only time such factors can be observed remotely. The discussion then focuses on describing the present ballistic missile test ranges of both the US and USSR and the capabilities each has of monitoring the other's tests. For the US a variety of remote sensing systems are used including:

- communications and telemetry interception equipment,
- radars (OTH and line-of-sight), and
- acoustic sensors.

Satellites, ships and land installations are all used in monitoring adversary flight tests. The SIPRI chapter concludes that the US has excellent resources for terminal phase monitoring of Soviet flight tests which is where the most important data is revealed. This ensures that the most important stipulations in the Treaty can be effectively verified.

Cruise missile testing poses a greater verification problem than for ballistic missiles from the US point of view because Soviet test ranges are outside the range of most US remote sensors.

Deployment of strategic weapons systems is monitored mainly by satellite. A brief discussion of the capabilities of photographic reconnaissance satellites is included.

The possibility of a strategic "breakout" -- that is, creation of a strategic military advantage through the clandestine production or stockpiling of weapons which could quickly be prepared for operational use -- is also addressed. SIPRI concludes the various scenarios suggested for such "breakout" are unlikely to occur.

Also presented is a useful table (pp. 304-308) which lists the aspects of SALT II requiring verification together with SIPRI's assessment of the verification techniques which will be used to monitor these restrictions. The SIPRI authors point out that, according to their table, there is at least one verification resource for virtually every verification requirement.

In the view of the SIPRI authors, the most serious verification problems may arise for the ICBM modernization program and the development of the new type of ICBM permitted under the Treaty, both of which require surveillance of missile flight tests. "The requirements of this task are known to be at the brink of the technical capabilities of existing verification systems" (p. 310). Additional problems could arise because of concealment or encryption of telemetry during tests. While this is generally banned by SALT II, the Treaty does not specify which transmissions should not be encrypted. SIPRI feels that in practice this will not be a serious problem. Any encryption or concealment will be readily apparent and would be raised in the Standing Consultative Commission. Because test programs require 20-30 tests over several years successful concealment would be very difficult.

Both governments seem to be satisfied that the verification system incorporated into SALT II will give them warning of any violation before it could pose a serious military risk.

Proposal Abstract J89(A81)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - missile tests
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - aerial
   - ELINT
   - ground-based
   - radar
   - satellite
   - shipboard

3. **Source:**
   Hussain, Farooq. The Future of Arms Control: Part IV, The Impact of Weapons Tests Restriction. Adelphi Papers #165. London: International Institute of Strategic Studies, 1981.

4. **Summary:**
Hussain gives a thorough review of modern techniques for monitoring missile flight tests. He divides these techniques into four categories: radars (both land- and ship-based), satellites, aircraft overflying impact areas and electronic intelligence obtained from telemetry interception. Each of these categories are discussed in detail, outlining their missions, capabilities and limitations. The emphasis is on US monitoring resources though some discussion of Soviet systems is included. Of particular note is Hussain's discussion of encryption and the vital importance of telemetry monitoring for verifying that new modifications and new equipment are not being tested. By their nature telemetry transmissions are highly susceptible to cheating regardless of whether encryption is used.

In general, Hussain concludes that while it is relatively simple to detect missile test launches with a high degree of assurance, it is much more difficult to monitor whether the flight is being used to upgrade the missile, its reentry vehicles or one of its subsystems. Present monitoring techniques have been able to observe a wide variety of qualitative improvements in ballistic missiles but this is more due to the fact that there has been little incentive to conceal these developments than to increased capabilities of the monitoring systems. It is also very unlikely that technical refinements of missile test monitoring methods will overcome the difficulties discussed in the paper.

A tight agreement to prevent any significant violation would require exhaustive definition of possible evasion methods and careful drafting to prevent them as well as redundant verification techniques

some of which would be highly intrusive. This would lead to a fractious negotiating process over emphasizing technical details. Past experience with SALT suggests as well that failure to detect violations is less a problem than knowing how to respond to a specific violation. The confidence-building benefits of a flight test agreement could easily be outweighed by these problems created by the need for verification.

On the other hand, violations, however technical, help undermine the perceived value of the arms control measure and the scope for technical violations is likely to be larger under test restriction agreements. Another disadvantage of flight test restrictions is that they may encourage development of alternative methods for evaluating strategic weapons which would be unverifiable.

Proposal Abstract J90(A81)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - anti-ballistic missile systems
   - manned aircraft
   - cruise missiles
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Katz, Amrom. "Verification and SALT: A Different Line of Insight". In Intelligence Policy and National Security, pp. 143-147. Edited by Robert Pfaltzgraff Jr., Uri Ra'anan and Warren Milberg. London: Macmillan, 1981.

4. **Summary:**

Katz discusses various deficiencies of the SALT agreements (see abstracts J67(T72) and J79(T79)). First, he notes that deterrence depends in part on the adversary's knowledge of one's weapons systems, their magnitude and capabilities. Before the SALT agreements were signed, American intelligence agencies benefited from a type of Soviet cooperation insofar as the Soviets did not conceal systems, which they otherwise could have. However, the SALT agreements gave them an incentive to hide systems.

Second, the SALT II Treaty is based on the premise that what is verifiable is significant and what is unverifiable is insignificant. Unfortunately, this is not the case.

Third, a deficiency of the SALT agreements is their sloppy, imprecise language which has been exploited by the Russians. The continuing interchangeability of the terms 'launchers' and 'missiles' has caused a lot problems, notably the Soviet move to cold-launch techniques after the Interim Agreement was signed in 1972. This can be explained by a number of possible reasons. Cold-launching allowed the Soviets to place a bigger missile in a smaller hole since the diameter of the silo includes room for the flame from a hot-launched missile. Another explanation is that after a cold-launch, the silo can be reused quickly. A third is that this enabled them to super-harden the silos with a smaller sealing door.

Fourth, there is no clear understanding of what is meant by "national technical means" and there is no explicit distinction made between these means and espionage satellites.

J91(A81)

Proposal Abstract J91(A81)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - manned aircraft
   - missile tests

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Levitt, Geoffrey. "Problems in the Verification and Enforcement of SALT Agreements in light of the Record of Soviet Compliance with SALT I". Harvard International Law Journal 22, no. 2, (Spring, 1981): 379-404.

4. **Summary:**

This article addresses the problem of Soviet non-compliance with the SALT I Treaty, and looks to the imprecise wording of the agreement itself as a cause of subsequent violations. Specifically, difficulties in both the verification and enforcement of compliance have arisen where poorly worded provisions have been open to interpretation. "A review of the record of Soviet compliance with SALT I reveals a clear need for more comprehensive and specific language in future SALT accords" (p.379). Some of these problems are also discussed in reference to SALT II, and the effect of its precise wording is considered.

SALT I

In order to demonstrate the way in which imprecise language gives rise to treaty violations, the major issues in Soviet non-compliance are reviewed. For example, the wording of the ABM Treaty has permitted circumvention by failing to specify those prohibited activities which are in an 'ABM mode'. Similarly, the Treaty had required that radar sites be limited to agreed test ranges, but it failed to say where such test ranges were located. In this instance, as in others, "it is evident that the Soviets were pressing on with their ABM testing and development program and that the United States had failed to incorporate language into the ABM treaty that would dependably prevent worrisome Soviet activity in this area" (p.383).

Another provision of the SALT I Treaty which has failed to restrict specific activities is that which prohibits interference with national technical means of verification. Both active and passive interference are prohibited; the former are those actions taken to attack the means of verification itself, while the latter refers to evasive tactics or the concealment of prohibited activities. Exceptions to these restrictions are made, however, as SALT I permits concealment where it is a 'longstanding practice' and the obligation

not to interfere with verification "shall not require changes in current construction, assembly, conversion or overhaul practices" (p.388). This has often been used by the Soviet Union as a defence of dubious activities. Consequently, the United States has been unable to establish clearcut violations of SALT I verification provisions: "The availability of these plausible justifications for actions which interfere with the crucial task of monitoring compliance represents another shortcoming of the SALT I Treaty" (p.389).

Special problems arose with the implementation of SALT I, as the ambiguity and imprecision of its language created 'serious obstacles' to effective verification and enforcement. Concealment practices of the Soviet Union frustrated US monitoring attempts, and these vague restrictions on interference with verification did nothing to alleviate the situation. Instead, SALT I provisions have had an 'asymmetrical effect', given the 'special needs' of the US and its limited access to information. This means that the Soviets have various alternative sources of information on US military capabilities, whereas the US must rely solely on its national technical means of verification for information on the Soviet Union. As a result, the Soviet Union stands to gain more from its concealment practices, since the US has no 'back-up sources' of information; "it would be far easier for the Soviet Union than for the United States to engage in militarily significant clandestine activity in violation of SALT agreements ..." (p.392).

The potential advantages which the Soviet Union might gain from concealment are further facilitated by a lack of any legal obligation in SALT I to observe provisions on verification. The Treaty only requires that parties act "in a manner consistent with generally recognized principles of international law..." (p.392). These principles are vague, 'notoriously fluid', and open to interpretation. On the issue of verification, international law is further complicated by the uncertain legal status of space-based surveillance systems. The Soviet Union is reluctant to recognize the legality of such satellites, simply because this ambivalence gives them more latitude for manoeuvring. It will be much more difficult to prove that interference with a satellite is in violation of the Treaty if the legal status of the satellite itself is called into question.

Another problem with SALT I verification provisions relates to those rules governing concealment. As was noted earlier, some concealment practices are permitted under SALT I so long as they are 'current' or 'longstanding' activities. The kind of practice permitted is not clearly specified, however. Thus, many dubious activities may be excused; while it is unlikely that the Soviet Union could get away with widespread, significant concealment, smaller violations are possible where the treaty language is vague. Thus, "the problem of the treaty language is more serious in the case of the concealment loophole. Concealment is less dramatic, less hostile, and more 'natural' than active interference; it is likely to be allowed to proceed much further than would active interference before negative political consequences begin to arise" (p.394).

Enforcement of SALT I has been hindered by the vague and ambiguous language of its provisions. An injured party to an agreement may be reluctant to enforce its provisions if it is not clear whether an activity is prohibited or merely questionable. Here, the Soviet Union has taken full advantage of vague wording, and their dubious activities were disregarded because it was not clear that they were actually violating SALT I. This confusion has also prevented the imposition of sanctions. It was impossible to determine the appropriate response where the nature and extent of the violation were uncertain. This is especially true of those violations which are passive, since such concealment practices are less dramatic or hostile, and thus render an effective immediate response less likely.

SALT II

Unlike SALT I, problems arising from the language of the treaty did not reach 'critical proportions' with SALT II. This is partly due to the fact that the agreement itself was not that restrictive, and there was accordingly little incentive for violations. In addition, the limits that it imposed were primarily quantitative and easily monitored, so that concealment and deception did not prevent effective verification. Finally, changes were made in the wording of the agreement, as the potential damage that might ensue from imprecise language was fully realized. SALT II thus provides an indication of the future direction for arms control; significant restrictions and imprecise wording are scrupulously avoided to allow for better verification and enforcement of agreements.

Those Soviet activities which are merely questionable under SALT I generally would be interpreted as 'clear violations' with the application of SALT II provisions. For example, the problem of determining whether the SS-19 is a heavy ICBM is resolved in SALT II; "the specific reference to the size of an existing missile, in this case the SS-19, provides greater certainty in both the verification of and adherence to the agreement because it provides a tangible, quantitative benchmark" (p. 399). Provisions are also made in SALT II to account for MIRVed missiles. While some loopholes remain, enforcement would be greatly facilitated under SALT II, should the same violations occur. Its substantive sections are clear, specific and detailed, and are accompanied by definitional sections which instruct interpretation of the Treaty.

There have been some improvements in the wording of clauses restricting interference with verification in the SALT II agreement. However, this Treaty continues to rely on "generally recognized principles of international law", yet it fails to indicate what these principles might be. The legal justification for sanctions is still unclear, so that legitimate interference with national technical means of verification "thus remains open to self-interested manipulation by the interfering party" (p.402).

Levitt concludes that there has been a substantial improvement in the language of SALT II with the introduction of clear, specific substantive provisions. The implementation of SALT I and ensuing

problems in non-compliance clearly demonstrated the 'serious weaknesses' in the agreement itself. "However, there is certainly still room for further improvement, particularly in the verification provisions" (p.403). "Generally recognized principles" should be clearly defined in order to provide a basis for assessment where potential violations occur. Responses to suspected violations would become "politically easier", since the nature and scope of a violation would be less ambiguous.

Proposal Abstract J92(A83)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - research and development
   - missile tests
   - mobile ballistic missiles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Kissinger, Henry. "A New Approach to Arms Control". Time (21 March 1983.)

4. **Summary:**

One of the central problems in arms control negotiations is the fact that they have been carried out in isolation from strategic considerations. Specifically, the demise of SALT negotiations may be traced to a previous reliance on the restrictions of delivery vehicles. Technological change and the development of multiple warheads has rendered this counting method obsolete, since one force may now overwhelm the other even where there is a relative equivalence in delivery vehicles. These developments have also posed a significant challenge to verification as the comparison of nuclear forces becomes more complicated or obscure. Consequently, a new scheme must be designed which takes into account such developments and seeks to establish a new 'strategic stability'.

It is posited that any future success in arms control depends on the ability to promote strategic stability by preventing a pre-emptive first strike. This can only be achieved by introducing a new approach which would eliminate multiple warheads and simultaneously render missiles less vulnerable to a first strike. Such a scheme might be implemented by developing a mobile missile with a single warhead. It is stated that "this scheme should pose no insurmountable verification problems". While these missiles would be harder to detect, their numbers would be sufficiently high that any violation large enough to significantly alter the strategic balance would be easily detected. Verification with regard to other missiles with multiple warheads would also become easier, since any new testing or development in this area would be proscribed.

Proposal Abstract J92.1(A83)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned bombers
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles
   - comprehensive test ban
   - fissionable materials 'cutoff'

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ELINT
   - ground-based
   - radar
   - aerial
   - shipborne

   (b) On-site inspection - selective
   - IAEA safeguards

3. **Source:**
   Federation of American Scientists. "Verifying a Model Freeze". Reproduced in <u>Congressional Record</u> (14 April 1983): S4616-S4621.

4. **Summary:**
The paper reviews US national technical means (NTMs) of verification. Imaging reconnaissance satellites include the following:

(1) KH-11 - This CIA satellite weighs about 10,300 kg and flies at an altitude of 300 to 600 km for up to two years. It can image wide areas or zoom in on smaller areas with a resolution of between two and five metres. The KH-11 does not use photographic film but instead employs an electronic imaging system; this permits it to transmit images to earth in real-time. Sensors on the KH-11 are probably multispectral.

(2) "Big-Bird" - This US Air Force Satellite weighs about 11,000 kg and flies at an altitude of 160 to 280 km for about six months. It uses photographic film to record images. Film of large areas is developed on board, scanned by a TV camera and the TV image is transmitted to earth. Film of specially chosen targets can also be returned to earth via four or six film pods carried by the satellite.

(c) "Close-look" - These satellites fly at altitudes of 80 to 90 miles for about 60 days. They can take pictures with a resolution of perhaps six inches. Film is returned to earth in pods. Their frequency of use has declined since the introduction of "Bid Bird". Both the "Big Bird" and "close-look" satellites will be replaced in 1984 by a large satellite with long lifetime.

Electronic reconnaissance satellites include the following:

(1) "Ferret" - These collect data on Soviet radar. Since few have flown recently, it is likely that "Big Bird" or the KH-11 can collect similar data.

(2) "Rhyolite" later renamed "Chalet" - These geosynchronous satellites collect telemetry from Soviet missile tests and military communications.

(3) Ocean reconnaissance - These operate in sets of four proximate satellites. By detecting radar and communications signals from ships they can locate the ships.

Missile warning satellites include the Defence Support Program Satellites which detect missile launches by infra-red detection of rocket plumes. They also carry visible light detectors and radiation sensors for detecting nuclear explosions and monitoring missile test launches.

Nuclear explosion detection satellites include the following:

(1) "Vela Hotel" - Two of these satellites still provide useful data from their detectors for monitoring nuclear explosions in the atmosphere and space.

(2) Defence Support Program Satellites

(3) Global Positioning System Satellites - These carry the Integrated Operational Nuclear Detection System which uses ultra-violet and x-ray sensors to give precise locations of nuclear explosions in the atmosphere and in space out to 11,000 km.

NTMs also include seismic sensors and the underwater acoustic surveillance system. Ground-based monitoring systems include electronic listening posts and special radars such as the phased array radar Cobra Dane. High-altitude reconnaissance planes (the SR-71, U-2 and TR-1) fly along coastlines and border areas peering into Soviet territory with side-looking radars, cameras and electronic receivers. Electronic intelligence ships include "Holystone" submarines which are nuclear attack submarines specially configured for signal and communications intelligence, as well as surface ships.

In addition, the paper mentions HUMINT which refers to information garnered from agents, defectors, emigrés, defence attachés, businessmen, and tourists as well as published literature.

The model comprehensive freeze proposed would involve seven components.

(1) Indefinite freeze on deployment of ICBMs, SLBMs, IRBMs and GLCMs. This can be adequately verified. ICBMs require extensive support facilities that are visible to NTMs. SLBMs can be verified by monitoring the launch, fitting out and sea trials of each submarine. Mobile ICBMs, IRBMs and GLCMs can be verified by monitoring their transport, security and launch control systems. In peacetime these mobile systems are deployed in main operating bases. Strategic bombers are large, built at only a few plants and deployed at a few bases that are monitored. Prohibitions on major modifications to existing missiles could be verified by monitoring the test component of the freeze.

(2) Numerical Freeze on Dual Capable Launch Platforms and Delivery Vehicles. Special training, communications, operations and security measures accompany nuclear certified units into the field making moderate to high confidence verification of these systems possible. LRINF missile deployments can be monitored by reconnaissance aircraft as well as electronic listening posts. A common database might be set up by the US and USSR and maximum allowable weapons load counting rules could be developed to ease verification. ALCMs can be monitored with high confidence by examining the aircraft on which they are deployed especially if counting rules like those of SALT II are adopted. SLCMs could be restricted to those ships which are identified as having a nuclear role at the time of the freeze.

(3) Delivery Vehicle Test Freeze. A set of percentage differences between old and new missile size and performance criteria could be used which could be monitored with high confidence by satellites, ground-based stations, and aircraft. A limit on the number of tests could similarly be monitored.

(4) Comprehensive Test Ban. The paper reviews the agreement reached by the Carter Administration with the USSR and the UK which included unmanned seismic monitors in each country integrated into a world wide seismic monitoring network. Other US collection systems including satellites, underwater sensors and atmospheric sampling aircraft also would be used. On-site inspections would be allowed in cases of doubt. A CTB would be adequately verifiable.

(5) Ballistic Missile Production Freeze. The US national intelligence system has amassed much knowledge concerning the Soviet ballistic missile production system. This in conjunction with current monitoring capabilities would permit verification of the shutdown of production plants. Voluntary data exchanges and on-site inspection might also be used to alleviate suspicions.

(6)&(7) Nuclear Warhead and Weapons-grade Materials Production Ban: A ban on nuclear warhead production could be implemented and verified along the same lines as the missile production ban. During the warhead production moratorium, IAEA safeguards agreements would be negotiated for all nuclear facilities and materials stockpiles. The CTB system of "voluntary inspections" to resolve suspicions could be used as well.

The paper includes a detailed table relating the monitoring tasks involved in verifying elements of the proposed freeze, on the one hand, to the intelligence systems that would be useful for verification, on the other.

J93(A84)

Proposal Abstract J93(A84)

1. **Arms Control Problem:**
   (a) Nuclear weapons - ballistic missiles
   (b) Regional arms control - outer space - ASATS

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) Complaints procedure - consultative commission

3. **Source:**
   Krepon, Michael. Strategic Stalemate: Nuclear Weapons and Arms Control in American Politics. New York: St. Martin's Press, 1984.

4. **Summary:**

The author reviews the history of nuclear arms control negotiations and the debate between "two camps" in the United States - those who advocate reliance on weapons and those who advocate negotiations to serve US interests. He urges that the two camps narrow their differences and unite in pursuing an effective compliance strategy to deal with Soviet violations of arms control agreements.

In the past, Krepon argues, weapon strategists insisted on excessive verification requirements. For example, they demanded on-site inspection for a ban on MIRV deployments when verification could have been provided by sophisticated monitoring devices (p. 169). Both arms controllers and weapon strategists realize that completely effective detection methods are not possible. The two camps should unite in advocating "the judicious use of safeguards" (p. 171) to promote compliance with arms control agreements and to assist in developing a strategy for responding to Soviet violations. The US should first try to resolve compliance problems through diplomatic channels before adopting countermeasures. The Standing Consultative Commission is an important forum for resolving compliance issues, but higher level diplomatic exchanges may be necessary.

Safeguards should be negotiated early on in discussions, not after agreements have been concluded. Safeguards for an ASAT agreement could include restrictions on testing in order to limit operational capabilities or a complete ban on tests. The US could develop a production line which can be opened if the Soviet Union resumes ASAT testing.

Proposal Abstract J94(A84)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - manned aircraft
   - fissionable material "cut-off"
   - comprehensive test ban
   - research and development
   - proliferation

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   - challenge
   - IAEA safeguards
   (c) Seismic sensors - intra-border stations
   (d) International exchange of information - declarations

3. **Source:**
   Stoertz, Howard Jr. "Monitoring a Nuclear Freeze". International Security 8, no. 4 (Spring 1984): 91-110.

4. **Summary:**

The author discusses the problems associated with verifying the nuclear freeze resolution passed by the US House of Representatives on May 4, 1983 (For the text of the resolution, see Congressional Record. Washington, D.C.: US Government Printing Office, May 19 1983, pp. E2389-90). He concludes that such a freeze would constrain US flexibility and that a pure, comprehensive freeze of this type is not feasible for large, existing forces. If it should ever be negotiated, however, then verification provisions should minimize areas of monitoring weakness.

American intelligence can monitor Soviet military activities well enough to satisfy national security needs and would therefore presumably be able to adequately monitor an arms agreement. The primary means of verification, national technical means (NTMs), however, cannot observe all activities. NTMs can monitor weapons systems which, because of their complexity, take a long time to build, are built in the open or are deployed at specialized facilities. Such systems include ICBM silos, submarines, bombers and anti-ballistic missile systems. NTMs are not as effective in verifying systems which are more rapidly built or are easily concealed. NTMs cannot observe activities inside buildings and covered facilities so that production is more difficult to monitor than deployment. Qualitative aspects of weapons systems are also difficult to verify. Range and payload capabilities can be altered without detection and this problem is particularly significant in the case of shorter-range systems which lend themselves to multiple uses.

Stoertz cautions against relying on published estimates of Soviet military production in US and other Western sources. Many of these estimates are derived indirectly from information about testing and deployment so they are subject to the same limitations in detection capabilities faced by national technical means.

After discussing American monitoring capabilities in general, the author proceeds to consider the monitoring implications of the House freeze resolution. NTMs would permit verification with only low confidence in the following areas: monitoring the production of missiles of all sizes and of the launchers of smaller systems such as short-range missiles, air defence and anti-submarine weapons; monitoring the deployment of smaller, short-range systems and cruise missiles; detecting the conversion of dual capable systems from conventional to nuclear missions; and distinguishing allowed safety modifications from prohibited performance improvements.

The CTB proposed in the resolution could be monitored with high confidence by a network of seismic stations in each country and an exchange of seismological data. A freeze on the production and deployment of nuclear weapons could be accomplished by shutting down large and easily identified weapons production facilities. IAEA safeguards could ensure that materials are not diverted from civilian nuclear power facilities to weapons production. Even with such safeguards, however, nuclear weapons could be produced clandestinely so that monitoring the production and stockpiling of more nuclear weapons could be accomplished with low confidence only.

On-site inspection is often proposed to solve difficult verification problems. Indeed, inspections on demand would yield high confidence in verifying a CTB and could contribute to confidence in monitoring large, long-range systems. However, on-site inspections would not detect weapons production in concealed alternative facilities and would have difficulty in monitoring small, short-range systems with nuclear warheads. Furthermore, there are other problems with on-site inspections: suspicious activities which warrant inspection-on-demand would have to be detected first by other means; the Soviets could delay demand inspections and thereby remove evidence of cheating prior to the inspection; and, in some instances, inspection may not be able to differentiate between prohibited activity and permitted activity (safety modifications, for example). Soviet reluctance to accept challenge inspections is another obstacle. For these reasons, reliance on on-site inspections as a supplement to NTMs is not a realistic possibility.

Rules and procedures agreed to in SALT negotiations would assist monitoring. These include: definitions and counting rules to distinguish delivery systems; procedures for dismantling, destruction and replacement which permit observation by NTMs; non-interference with NTMs; elimination or modification of ambiguous systems; and the exchange of information concerning the testing and introduction of new systems. An exchange of information including declarations of all ships carrying long-range cruise missiles by type and number could also facilitate verification of extra long-range cruise missiles with sea-based launchers.

Proposal Abstract J95(A85)

1. **Arms Control Problem:**
   Nuclear weapons - ballistic missiles
   - cruise missiles
   - comprehensive test ban
   - partial test ban
   - missile tests

2. **Verification Type:**
   (a) Remote sensors - satellites
   - aerial
   - ELINT
   - ground-based
   - radar

   (c) Seismic sensors
   (b) On-site inspection - selective
   (d) Short-range sensors - monitoring devices

3. **Source:**
   Smith, R. Jeffrey. "High-Tech Vigilance". <u>Science 85</u> (December 1985): 26-33.

4. **Summary:**

For more than 30 years the US has used its monitoring technologies to check for ominous international developments. Nations that know what their enemies are doing are less likely to increase world tensions through actions resulting from fear. Nations that know that their enemies are similarly observing them are less likely to threaten peace by rash behaviour. Governments are also more likely to conclude treaties if they can verify their opponent's compliance.

In the past, as weapons technology advanced, so too did monitoring technology. This bought time for diplomats to work out ways to prevent tensions escalating into war. Recently, however, some high US officials have questioned the ability of monitoring technology to keep up with Soviet weapons development.

US monitoring systems fall into two categories: "surrogate eyes" and "surrogate ears". The former includes the KH-9 or "Big Bird" satellite which orbits about 100 miles above the earth and can photograph all of the USSR and China every three and a half days. Events in other nations can also be observed as was the case for suspected nuclear tests in India in 1979 and South Africa in 1977. The KH-8 whose orbit is more elliptical than that of the KH-9 can photograph from 80 miles altitude. It was used in 1981 to monitor Soviet troop movements near Poland. Both the KH-8 and KH-9 carry a variety of cameras. Exposed film is parachuted back to earth where it is collected by planes or retrieved by divers. A resolution of

objects of 6 inches from 80 miles distance has been reported. The KH-11 records events in its field of view as digital electronic impulses instead of film. These can be transmitted directly to earth almost instantaneously, though the resolution is poorer than for photographs.

When events outrun the ability of satellites to be moved into position, reconnaissance planes can be used. The SR-71 or "Blackbird" can fly at more than 2000 mph at heights up to 85,000 feet. Its three cameras can film 100,000 square miles in an hour. It can produce three dimensional images of a 150 square mile area sharp enough to permit identification of mailbox on a country road.

Typically, one monitoring system will provide clues for additional investigation by other systems. All reconnaissance satellites are used in concert with sensors intended to monitor electronic communications; this combination of methods was used in October 1973 when it appeared the USSR was about to send troops into the Middle East war. These "surrogate ears" are located aboard satellites, aircraft, ships, submarines and at ground stations. They monitor not only telephone traffic but also radio, microwave and satellite communications as well as radar emissions and telemetry from missile tests. The primary listening satellites are the Rhyolite, Chalet and Magnum. The geosynchronous Rhyolite monitors information from Soviet missile tests. A different type of listening satellite known as White Cloud can intercept submarine and ship communications while another at a lower altitude monitors military radar transmissions. Supplementing these satellites are U-2, SR-71 and RC-135 aircraft.

The most important ground-based radar is Cobra Dane on Shimya Island off Alaska. It can detect an object the size of a basketball at 2000 miles. A similar radar called Cobra Judy is located on a ship. In addition, there is a world-wide network of ground-based antennas which monitor communications. These include antennas on tops of embassies.

Much of the information obtained from these monitoring devices is inferential. For example, in the case of a missile test, design details can be deduced from telemetry; radar returns permit estimates of velocity and acceleration; and imagery helps identify the fuel used and the missiles' point of impact.

Other satellites make up the Satellite Early Warning System which senses infra-red radiation emitted when an ICBM is launched. They can also detect nuclear explosions in the atmosphere and in space. Sensors on the new NAVSTAR navigation satellites will check for any nuclear detonations in space using x-ray, optical and electromagnetic pulse sensors. The data collected should permit the location of a nuclear detonation to within a mile almost immediately. The space-based Teal Ruby infra-red detection system is scheduled to be tested in 1986. It is intended to track flight paths of aircraft and possibly ICBMs.

The US also employs seismometers to detect underground nuclear blasts. Older Vela satellites monitored x-rays, gamma rays and

neutrons to check for atmospheric blasts. On September 22, 1979, a Vela satellite detected an incident which suggested that there was a nuclear test off South Africa's coast, but a controversy developed when the evidence did not permit confirmation of a detonation.

These systems, however, can be fooled either intentionally or unintentionally. The author cites several examples. In the past, US intelligence experts considered these incidents to be anomalies, but officials of the Reagan administration now claim that US monitoring technology is no longer competent to verify treaty compliance. The author cites as examples of future problems for monitoring: the SS-24 rail mobile ICBM whose transporter will be indistinguishable from ordinary rail cars, nuclear armed cruise missiles which are indistinguishable from their conventionally armed siblings, and the US ASAT system based on a modified F-15 fighter which is indistinguishable at a distance from an ordinary F-15.

In the case of cruise missiles, on-site inspections to detect the nuclear warhead's radioactive emission, will probably have to take place at production or deployment sites and possibly at both. But first every production site must be identified and monitors must be created and installed which can detect every weapon but not sensitive design and production information. Ports might have to be monitored and ships boarded. The only actual experiment with an on-site weapons detection system was carried out in 1984 at the General Dynamics cruise missile production plant in San Diego where a small, tamper-residant television camera was placed outside the gate and attached to a cable that detected the passage of trucks. This preliminary experiment worked. Other devices used in nuclear power plant monitoring might also prove useful, such as tamper-proof identification plates. These would be attached to weapons at production plants and later checked at deployment sites. But such systems require a high degree of intrusion.

A concerted effort to develop new verification technologies is needed. However, open portions of the US verification budget indicate that effort has slackened considerably in recent years; for example, the funding for new verification projects at Los Alamos Laboratory was reduced by 25% between 1984 and 1985. One exception to this trend was the addition by Congress of $7.5 million to the verification budget of the Department of Energy.

J95.1(A85)

Proposal Abstract J95.1(A85)

1. **Arms Control Problem:**
   (a) Nuclear weapons - ballistic missiles
   - cruise missiles

   (b) Conventional weapons - ships

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Byers, R.B. "Verification and Seapower: Soviet-American Perspectives on Compliance". In <u>The Denuclearisation of the Oceans</u>, pp. 212-228. Edited by R.B. Byers. Beckenham, England: Croom Helm Ltd., 1986.

4. **Summary:**

Mechanisms and structures used to determine whether all parties comply with the provisions of an agreement are a concern in all arms control negotiations. While on the surface the tasks relating to compliance and verification appear straightforward, they are complex and contentious because of three interrelated problems (in ascending order of important): conceptual, technical and political. Technical issues relating to naval weapons (such as the total numbers of sea-based nuclear platforms, their range in size, their mobility and the dual capability of most platforms) suggest that NTMs will need to be supplemented by cooperative measures.

The author believes that "in the final analysis the real problems are neither conceptual or technical -- rather they are political" (p. 216). He reviews Soviet and American views on compliance and verification at some length concluding that the USSR has accepted the principle that in some circumstances cooperative measure are required to verify compliance.

A concern to both superpowers is the possibility that non-compliance could result in advantages to one side. Four such advantages are identified and related to naval arms control:

(1) Demonstration advantages are ones which have political implications but no military significance. An example is trespassing into agreed SSBN sanctuaries. Cooperative measures would be required to ensure that such advantages do not become the norm.

(2) R & D advantages would result if a party circumvents limits on SLCM ranges or flight tests of new classes of SLBMs. Cooperative measures could greatly reduce dangers of R & D advantages.

(3) Balance advantages result from violations which affect military capabilities quantitatively or qualitatively. Deployment of nuclear SLCMs could lead to balance advantages if compliance measures are limited to NTMs. Limits on sea-based tactical nuclear platforms and specific types of nuclear systems would also require some form of cooperative measures.

(4) Tactical and/or strategic breakout advantages might result in a first-strike capability. NTMs are "more than sufficient" to detect strategic breakout. Similarly, tactical breakouts, such as a breakthrough in ASW which threatened SSBNs, are also unlikely given the use of NTMs.

The author lists several concluding observations:

(1) There is no prospect that the superpowers will conclude a militarily significant treaty without being satisfied with the compliance/verification aspects.

(2) There is and will remain minimal prospect, in view of NTMs, that non-compliance could produce significant military advantage for either superpower.

(3) In periods of low tension, unlike the 1980s, the political significance of compliance assumes less importance.

(4) It is highly unlikely that superpowers would agree to international monitoring mechanisms of significant military assets including most naval systems. An exception might be zones of peace or nuclear weapons free zones.

(5) Certain nuclear capabilities including many naval platforms and systems, such as SLCMs, are becoming increasingly difficult to verify by NTMs.

(6) The prospects of adopting cooperative measures is a function of political climate. The USSR still has a long way to go to accept the need for cooperative systems.

(7) Specific types of naval arms limitation options and proposals should be assessed in terms of the mix of NTMs and cooperative measures required to verify compliance.

J95.2(A86)

Proposal Abstract J95.2(A86)

1. **Arms Control Problem:**
   (a) Nuclear weapons - ballistic missiles
   - comprehensive test ban
   - cruise missiles
   - fissionable material "cutoff"
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - proliferation
   - reentry vehicles

   (b) Regional arms control - outer space - ASATs
   (c) Any arms control agreement

2. **Verification Type:**
   (a) Remote sensors
   (b) Seismic sensors - extra-border stations
   - intra-border stations

   (c) Short-range sensors - monitoring devices
   (d) On-site inspection - IAEA safeguards
   (e) Verification, general

3. **Source:**
   Tsipis, Kosta, David W. Hafemeister and Penny Janeway. Editors. Arms Control Verification: The Technologies That Make It Possible. McLean, Virginia: Pergamon-Brassey's International Defence Publishers, 1986.
   See also: - Abstract K45(G84)

4. **Summary:***

This volume is a collection of papers originally presented at a conference of specialists on the technical means of verifying compliance with arms control treaties, held in February 1984. The participants at the conference sought to explore the minimum requirements for information about Soviet activities and weapon systems given the need to safeguard US national security and then compare these requirements with existing and projected monitoring capabilities. Broader political, diplomatic and compliance issues were also noted.

One conclusion of the conference is that technology permits the US "to monitor with confidence much, although by no means all, of the weapons-related activities of the Soviet Union, and that the level at

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* This book was received too late for a detailed summary to be prepared.

which the technology functions is higher than has generally been recognized" (p. x). In addition, violations of nuclear arms treaties that could seriously undermine US security are well within the detection capabilities of present US verification technologies irregardless of expected improvements in those systems.

Table of Contents

 J96(A72)

Proposal Abstract J96(A72)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Olgaard, P.L. "Verifying a Comprehensive Test Ban", Survival 14, no. 4 (July/August 1972): 162-168.

4. **Summary:**
   This proposal suggests that a comprehensive test ban could be verified with the use of satellite sensors. Preparatory work connected with clandestine tests, such as the drilling of holes, could be observed from space. The author maintains that even if such a test were conducted in alluvium soil, a medium well suited to absorbing large explosions with minimal observable effects, it would be observable by certain kinds of sensors. Temperature increases at the surface above the explosion would show up if infra-red optics were used, while accidental radioactive emissions would also be detectable.

J97(G77)

Proposal Abstract J97(G77)

1. **Arms Control Problem:**
   (a) Nuclear weapons - comprehensive test ban
   (b) General and complete disarmament
   (c) Chemical and biological weapons

2. **Verification Type:**
   (a) Remote sensors
   (b) Seismic sensors
   (c) On-site inspection - selective
   (d) International control organization
   (e) International exchange of information

3. **Source:**
   United Kingdom. British Information Services. Arms Control and Disarmament. London: Central Office of Information, October 1977. RCO 31/77 UK 1 C152, R6031.

4. **Summary:**

This pamphlet provides some important insights into the problem of verification as it has evolved in the post-war period. The official position of the United Kingdom on verification is also described. One of the basic problems has been a 'fundamental difference' in methods or aims between the Western nations and the Soviet Union. The Western world seems prepared to accept infringements on its sovereignty and economic organization where necessary to maintain national security; in comparison, "the Government of the USSR puts its sovereignty first and is unwilling to accept measures which may impinge upon or interfere with its rigid exercise of unimpeded state sovereignty" (p.4). It is this fundamental disagreement which has led Western countries to demand effective verification of any reduction of arms, whereas the Soviet Union has consistently refused to allow on-site inspections and other intrusive means of verification.

It was recognized early in the disarmament process that any attempt to regulate or control nuclear weapons would leave open the possibility of evasions. Consequently, disarmament negotiations began to focus on partial measures "as first steps towards the ultimate goal of complete disarmament" (p.5). Although the earliest Soviet proposals stressed the risks inherent in complete disarmament, they later insisted that comprehensive proposals be put forth in the first stages of disarmament, prior to any requirements for verification. The response of the United States, as supported by Britain, was essentially that verification must be conducted before reductions took place, to provide assurance that agreed levels are being met. The Soviet Union has consistently rejected verification prior to reductions on the grounds that this amounts to espionage and control over armaments.

A number of disputes over verification have arisen in negotiations for a comprehensive test ban. The Soviet Union contends that seismic detection alone will ensure compliance with a test ban, while the West demands some form of on-site inspection in addition to national technical means of verification. The official British position is essentially that, despite recent technological developments in seismic detection, "seismology still has serious limitations as a tool for identifying nuclear explosions below a certain strength" (p. 13). No specific reference is made to the necessity of on-site inspection, but it is stressed that the verification measures used must reduce risks and provide increased confidence.

Chemical and biological weapons also pose significant problems for verification and arms control, since any prohibition of these weapons will require on-site inspection and other intrusive verification measures. Britain has suggested that agreements might proceed in stages, beginning with partial measures which require less intrusive verification schemes. A British draft convention was submitted to the Conference of the Committee on Disarmament in 1976 (see CD/512, abstract M18(G76)). It is a comprehensive proposal which is to be applied in successive phases, and would establish an international inspection body to conduct verification, inspection and data exchanges.

J98(A83)

Proposal Abstract J98(A83)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   Remote sensors - radar

3. **Source:**
   Warshaw, Stephen and Paul Dubois. "Ionospheric Detection of Explosions". Energy and Technology Review Lawrence Livermore National Laboratory (May 1983): 38-49.

4. **Summary:**
   This technical article describes the work of Lawrence Livermore National Laboratory in developing computer simulation codes and theoretical models to account for atmospheric and ionospheric phenomena relevant to ionospheric detection of underground nuclear explosions. The detection method involves the use of high frequency radar to detect electronic perturbation in the ionosphere caused by an explosion. Tests have measured the acoustic pulse and ionospheric disturbance of underground nuclear explosions as well as for a ground-based chemical explosion. The results have produced "some very encouraging calculations" (p.39) which suggest that the method deserves serious consideration as a means for remotely sensing the effects of an explosion.

Proposal Abstract J99(G83)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   Remote sensors - sampling

3. **Source:**
   Sweden. "Working paper: International Surveillance of Airborne Radioactivity (ISAR)". CD/403, 11 August 1983.
   See also: - Sweden. "An international system for the detection of airborne radioactivity from nuclear explosions". CD/257, 8 March 1982.

4. **Summary:**

   This paper discusses the design and cost aspects of a system to monitor airborne radioactivity, proposed in working paper CD/257, which could be used to verify a comprehensive test ban. Developments in techniques for analysing radiation from dispersed remnants of a nuclear explosion have replaced an older time-consuming procedure with a method employing a single measurement using a germanium detector. This new method permits the detection of debris from a nuclear explosion and a determination of the time since the explosion, with a high degree of certainty.

   A system for the International Surveillance of Airborne Radioactivity (ISAR) should consist of 50-100 fully equipped sampling stations and about six regional measurement stations. Sampling stations would cost approximately $20,000 (US) to establish and $10,000 annually to operate. A regional laboratory (of the same size as the Swedish measurement laboratory) would cost approximately $700,000 to establish and $300,000 for operations annually (costs of premises not included). The whole international system would thus cost less than $10 million to establish and less than $3 million to operate each year. This system would establish facilities which could be shared by data centres involved in the collection and analysis of seismic data for monitoring a comprehensive nuclear test ban treaty.

   A meteorological study conducted in the winter 1982-83 by the University of Stockholm suggested an arrangement for collection stations which would ensure even distribution of sampling and a similar detection probability at points all over the globe.

J100(G83)

Proposal Abstract J100(G83)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   (a) Remote sensors
   (b) International control organization
   (c) International exchange of information
   (d) On-site inspection - selective
   - non-obligatory
   (e) Complaints procedure - referral to Security Council

3. **Source:**
   Union of Soviet Socialist Republics. "Basic provisions of a treaty on the complete and general prohibition of nuclear weapon tests". CD/346, 16 February 1983.

4. **Summary:**

This document proposes a combination of national and international means of verification. Remote sensing by "national technical means" would be the national means of verification. International measures within the framework of the United Nations would be carried out by a Committee of Experts. States would also consult and cooperate with each other in exchanging information necessary to resolve questions related to compliance.

An international exchange of seismic data would also facilitate verification. Parties would have the right to contribute and receive data made available through the exchange. Data would be transmitted through the Global Telecommunications System of the World Meteorological Organization or through other agreed channels. International seismic data centres would be under the jurisdiction of the state on whose territory they are located. The Committee of Experts, composed of representatives of parties to the treaty and functioning on the basis of consensus, would regulate the establishment and operation of the international exchange of seismic data and would draw upon the recommendations contained in the report of the Ad Hoc Group of Scientific Experts (see abstract K33(I79)).

A party which suspects that a nuclear explosion has occurred on the territory of another party may send a request to that party, accompanied by the reasons for the request and relevant seismic or other physical data, for an on-site inspection. The state receiving the request may grant it, or reject it in which case it would explain the refusal to the requesting state and the Committee of Experts. If it is unsatisfied with the reasons for refusal, the requesting state

may ask the Committee of Experts for information and assistance in ascertaining the facts. Procedures for on-site inspection consented to by states, including the details of rights and functions of inspecting personnel and the role of the party being inspected, would be elaborated in the treaty.

A state suspecting a violation of treaty obligations may lodge a complaint (with accompanying relevant information and possible evidence) with the Security Council. The Security Council may conduct an investigation and would report the results. Parties would undertake to assist any party which requests help if the Security Council deems that the party has been exposed to danger because of a treaty violation by another party.

5. **Selected Comments of States:**

Some states such as Sweden and Belgium (CD/PV.182, 26 August 1982) support an international verification system for a CTBT including an exchange of seismic data and atmospheric monitoring. Other states such as Czechoslovakia (CD/PV.182, 26 August 1982) emphasize the need for national verification measures. Czechoslovakia (CD/PV.205, 22 March 1983) supports the Soviet proposal that information collected by national technical means should be made available to all parties, especially those which do not possess national technical means of verification. Bulgaria (CD/PV. 199, 1 March 1983) supports a combination of national and international means of verification.

Australia (CD/PV.209, 5 April 1983) poses a number of questions about the Soviet "Basic provisions" related to the mandate of the Committee of Experts (seismic verification only or atmospheric detection?), the complaints procedure, the authority to organize on-site inspections (who possesses it?) and the role of the Security Council or other UN bodies including the Committee on Disarmament in the process.

A debate also exists over the question of whether current verification technology is adequate to detect and identify seismic events for a CTBT. Japan (CD/PV.259, 17 April 1984) comments that not all underground explosions may be detected and identified so the verification system has to be upgraded with advances in seismology and the incorporation of a number of so-called "black boxes". The US (CD/PV.296, 5 March 1985) believes that existing technical means of verification are not sufficient for monitoring a CTBT. Belgium (CD/PV.301, 21 March 1985) states that information suggests that a nuclear explosion can be camouflaged so that it appears as earthquake activity, therefore scientific and technical work must continue. The FRG (CD/PV.307, 11 April 1985) says that there are outstanding problems connected with distinguishing nuclear explosions from other seismic events. Many other countries, however, suggest that current verification technology is adequate. The USSR, for example, (CD/PV.283, 21 August 1984) states that authoritative experts have

confirmed the possibility of effectively verifying a nuclear test ban with national technical means. In response to a question about verification in the context of the Soviet moratorium on nuclear explosions. Mikhail Gorbachev stated that "the existing scientific and technical capability here, in the United States and in other countries provides the necessary degree of certainty that a nuclear explosion, even a low yield one, will be detected." (See "Letter dated 19 August 1985 addressed to the President of the Conference on Disarmament from the representative of the Union of Soviet Socialist Republics transmitting the answers by Mikhail Gorbachev, General Secretary of the CPSU Central Committee, to a Tass correspondent published on 14 August 1985". CD/638, 20 August 1985, p. 3). Sri Lanka (CD/PV.308, 16 April 1985) suggests that current techniques for monitoring seismic waves can detect tests down to explosions of one kiloton.

Proposal Abstract J101(G84)

1. **Arms Control Problem:**
   Nuclear weapons - comprehensive test ban

2. **Verification Type:**
   (a) Remote sensors
   (b) Seismic sensors - international network
   (c) International exchange of information
   (d) On-site inspection - obligatory
   (e) International control organization

3. **Source:**
   Australia. "Working paper: Principles for the verification of a comprehensive nuclear test ban treaty". CD/531, 6 August 1984.

4. **Summary:**

This working paper outlines the principles and components of a verification system for a CTBT. The system would involve national and international measures including:

(1) national technical means;
(2) an international seismic detection network;
(3) an international atmospheric detection network;
(4) other international detection systems deemed necessary (i.e. using other technologies);
(5) on-site inspection; and
(6) a multilateral organ or organs to handle consultation, cooperation and complaints.

The international detection network should be established using the knowledge accumulated by the Ad Hoc Group of Scientific Experts to Consider International Cooperative Measures to Detect and Identify Seismic Events. The seismic monitoring system should consist of: a network of seismic stations, an international exchange of seismic data, and international data centres. On-site inspection would be mandatory.

J102(A77)

Proposal Abstract J102(A77)

1. **Arms Control Problem:**
Nuclear weapons - cruise missiles

2. **Verification Type:**
Remote sensors - satellite

3. **Source:**
Tsipis, K. "Cruise Missiles". Scientific American 236, no. 2 (February 1977): 20-29.

4. **Summary:**
The author analyses several arguments concerning the value of different types of cruise missiles. He notes that national technical means of verification could distinguish between tactical and strategic cruise missiles on three counts:

(1) Tactical cruise missiles have a volume of less than half a cubic metre, while strategic cruise missiles have volumes greater than half a cubic metre.

(2) Tactical cruise missiles are powered by turbojet engines while strategic models are powered by turbofan engines.

(3) Tactical cruise missiles have a thrust of less than 600 pounds, while strategic models have a thrust of over 600 pounds.

From these criteria it is possible to differentiate between strategic and tactical cruise missiles on the basis of the characteristic thrust signature left by all missiles. This can be accomplished by reconnaissance satellites using infra-red devices.

Proposal Abstract J103(A83)

1. **Arms Control Problem:**
   (a) Nuclear weapons - cruise missiles
   (b) Regional arms control - outer space - ASATs

2. **Verification Type:**
   Remote sensors - satellites
   - radar

3. **Source:**
   Einhorn, Martin B., Gordon L. Kane and Miroslav Nincic. "Strategic Arms Control Through Test Restraints". International Security 8, no.3 (Winter 1983/84): 108-151.

4. **Summary:**

This article considers in detail the prospects for partial or total test bans as a means of checking technological developments in strategic weaponry. Some important issues in verification arise, both in terms of the verifiability of test bans in general, and in relation to monitoring prospects for elusive weapons such as the cruise missile.

It is acknowledged that verification has been a major obstacle in the past and has been further hindered by the closed nature of Soviet society. While verification is a necessary component of any arms control agreement, some chance of violation will always remain, so that a less than perfect or adequate level of verification must be found. Some criteria are suggested: the likelihood of successful cheating, the military and political costs of evasion and the cost of rejecting a given agreement. Finally, the means of verification should be specifically tailored to the agreement that is to be enforced. It is concluded that the outlook for verification is promising in view of the Soviet Union's increasing openness, but this optimism is tempered by the new challenges presented by the latest weapons developments.

One such weapon which is difficult to verify or monitor at the testing stage is the cruise missile. This missile has a low altitude flight which allows it to evade radar detection; it also has a small radar cross-section. The cruise missile may thus be tested on a more limited and discreet level, outside the range of over-the-horizon radars and at undesignated testing sites. This will pose a significant problem for the verification of a test ban on cruise missiles. The authors suggest, however, that one might distinguish between subsonic and supersonic cruise missiles, and it is only the former which presents insuperable difficulties for verification. "There would seem to be technical factors militating somewhat against supersonic long-range CMs, inasmuch as the radar cross-section and detectability by Doppler radar increases with increasing speed, and a faster missile (which experiences much greater drag) presumably must

fly higher to attain a useful range with reasonable fuel economy and to maintain responsiveness to changes in terrain" (p.128). It is therefore recommended that those supersonic cruise missiles with a range exceeding 600 km be banned. The impact of remaining cruise missiles on crisis stability will be negligible given that the slower undetectable cruise missiles would not be an effective first strike weapon. Consequently, a test ban for long-range supersonic cruise missiles might help to maintain crisis stability and would be verifiable insofar as faster, higher flights or rocket powered cruise missiles can be detected using radar. Difficulties remain in that it is impossible to distinguish a conventionally armed cruise missile from a strategic one. While the maximum range of the missile might give an indication of its mission, the cruise needn't be tested at its full range, so that its real capability remains unknown.

Another area of weapons development which might be subject to a test ban is anti-satellite (ASAT) weapons. These will have a direct impact on verification insofar as they are a potential threat to a nation's satellites including those used for verification. Different kinds of ASAT systems will affect crisis stability to varying degrees, and some will be more amenable to a test ban than others.

A test ban on anti-satellite weapons would not only be desirable and feasible, but it would also be verifiable. It is acknowledged that verification capabilities for monitoring activities in outer space are largely unknown, but advancements in sensor technology are anticipated which would facilitate the task of verification. For example, improvements in non-optical infra-red millimetre wave sensors and synthetic aperture radar which allow better night-time and all-weather observation will also enhance space-based monitoring systems. The HALO technology program (High Altitude Large Optics) has developed a mosaic focal plane infra-red detector which is capable of detecting and tracking spacecraft, aircraft and cruise missiles. Another project "is proceeding with its satellite infra-red experiment to demonstrate feasibility of long wavelength infra-red sensors in detecting and tracking objects in space" (p.138). It does so by detecting the thermal radiation of objects against the 'coldness of space'. While the Soviet verification capability is largely unknown, they probably lag behind US abilities. This shortcoming is offset, however, by the Soviet Union's lesser requirement for verification. Thus, "it seems quite possible, given existing monitoring capabilities, to follow killer satellites placed in orbit by missile launchers" (p.139).

Some problems of verification are foreseen with the development of anti-satellite weapons, however. It may be difficult to detect and monitor such weapons placed in space via a space shuttle. US interceptor anti-satellite weapons which are launched from aircraft will also be hard to monitor, since they may be launched without

warning or any "obvious prelaunch preparations". Infra-red detectors may assist in detecting such weapons; "they will reportedly be able to monitor aircraft and perhaps even cruise missiles, and they could presumably identify a short-range attack missile (SRAM) above the atmosphere as well" (p.139).

Proposal Abstract J104(A83)

1. **Arms Control Problem:**
   Nuclear weapons - cruise missiles

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Hagen, Lawrence. Air-Launched Cruise Missiles: Implications for Deterrence Stability, Arms Control and Canadian Security. Ottawa: Operational Research and Analysis Establishment, Department of National Defence, October 1983. Project Report No. 214.

4. **Summary:**

This report addresses three questions about the air-launched cruise missile (ALCM): whether the ALCM is a stabilizing or destabilizing weapon system, what the impact of the ALCM will be on the prospects for successful arms control and what effect deployments of ALCMs would have on Canadian security. The report reviews the negotiating experiences with cruise missiles during the SALT II discussions and the author concludes that both superpowers "have been satisfied with the verifiability of air-launched strategic cruise missiles in the past" (p.23). SALT II handled verification problems by counting cruise missile carriers (heavy bombers) rather than missiles themselves. Submarine- and ground-launched cruise missiles (SLCM, and GLCMs) are more difficult to verify; national technical means can verify numbers of bombers for ALCMs, but not warhead type for SLCMs and GLCMs. Light nuclear warheads can be substituted for heavier conventional warheads thereby extending the range of the missile. However, the author asserts that because of their slowness in comparison with ICBMs, the three types of cruise missiles are not destabilizing first-strike weapons, therefore "the need for precise verification is arguably less severe than with other systems" (p.25). Hence confidence with regard to precise numbers of SLCMs and GLCMs is not necessary. Furthermore, current verification methods can create high confidence by detecting deployments of GLCMs. Satellites can 'sample' deployment sites to determine adherence and can monitor the deployment pattern of cruise missiles and the size of garages for potential reloads or refires. Verification of cruise missiles was an issue at the INF negotiations in Geneva and the US appeared confident that the problem could be dealt with. Verification of ALCMs in START negotiations could utilize the same formula as that used in SALT II.

 J105(A83)

Proposal Abstract J105(A83)

1. **Arms Control Problem:**
   Nuclear weapons - cruise missiles

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Longstreth, T.K. "Cruise Missiles: The Arms Control Challenge". Arms Control Today 13, no.4 (May 1983): 1-11.

4. **Summary:**
This article states that cruise missiles pose "unprecedented difficulties" for verification of arms control agreements. In particular, submarine-launched cruise missiles (SLCMs) and ground-launched cruise missiles (GLCMs), which were not effectively dealt with in the SALT II agreement, pose special problems. Cruise missiles are much smaller than ballistic missiles and can be launched from a number of different platforms. This creates difficulties for monitoring launches and support facilities using satellites and other national technical means. Deployment plans for SLCMs create further verification obstacles; SLCMs may be placed aboard traditionally non-strategic vessels (surface combatants and attack submarines), they may be deployed with non-nuclear SLCMs from which they are indistinguishable and, if they are placed in torpedo rooms of submarines and launched from torpedo tubes, they will be impossible to detect and count.

A ban on all types of SLCMs would be the most attractive arms control solution, but this is not likely to be advocated because of SLCM versatility, lethality and cost which makes them useful in the eyes of defense planners. Nonetheless, a ban on SLCMs with a land-attack capability, i.e. those SLCMs with ranges in excess of the longest anti-ship version, could be verifiable through monitoring flight test telemetry and other observable missile characteristics such as fuel consumption rate and estimated fuel capacity which give indications of range capabilities. The author cautions that such a ban would be difficult to negotiate because of the advanced stage of American and Soviet long-range SLCM testing, but notes that a Soviet START proposal included restrictions on SLCMs with ranges above 372 miles. It might also be possible to reduce counting and verification problems by prohibiting SLCM deployment aboard attack submarines (the most difficult platform for counting) or by designating ships and submarines that carry long-range SLCMs as strategic systems and hence subject to limitations.

Proposal Abstract J106(A84)

1. **Arms Control Problem:**
   Nuclear weapons - cruise missiles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Inglis, D.R. "Freeze the Cruise". Bulletin of the Atomic Scientists 40 (January 1984): 48-50.

4. **Summary:**
   The author suggests that the requirements for verification of a cruise missile "freeze" are different from those for a general nuclear weapons freeze. Verification of a cruise freeze would require only detection of whether the Soviets have produced and deployed massive numbers of cruise missiles. Such massive production could be detected adequately with national means of verification since "strict" verifiability would not be necessary. A freeze would be a temporary agreement pending more formal agreements containing explicit provisions for verification. Demands for strict verifiability would delay or eliminate the possibility of a quick freeze on cruise missiles.

Proposal Abstract J107(A85)

1. **Arms Control Problem:**
   Nuclear weapons - cruise missiles
   - manned aircraft

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) On-site inspection - obligatory
   - challenge

3. **Source:**
   Wilkening, Dean A. "Monitoring Bombers and Cruise Missiles". In Verification and Arms Control, pp. 107-123. Edited by William C. Potter. Lexington, Mass.: D.C. Heath and Co., 1985.

4. **Summary:**

This article evaluates the extent to which bomber and cruise missile characteristics and activities can be monitored by national technical means (NTM). The author uses an evaluation classification of high, medium or low monitoring confidence, depending on the ease of obtaining information by national technical means. He states that "high confidence reflects an optimistic assessment of monitoring capability, while low confidence implies that NTMs alone probably cannot provide sufficient data to assess treaty compliance reliably" (p. 108).

Monitoring confidence with regard to bombers is examined in four areas. First, identifying and counting aircraft using functionally related observable differences (FRODs) and externally observable differences (EODs) can be accomplished with high confidence. A significant problem, however occurs in determining which aircraft types can perform bombing missions. Soviet use of bomber airframes for non-strike aircraft complicates monitoring. Consequently, identification of designated bombers can be accomplished with high confidence, but confidence is moderate to low for determining that non-strike aircraft cannot perform bombing missions.

Second, NTMs can measure a bomber's unrefueled cruising range with moderate confidence and identify an in-flight refueling capability as long as external refueling probes are visible. A covertly-deployed refueling capability would be hard to detect, but this may be inconsequential since aircraft can be given an in-flight refueling capability or converted to use as tankers within several weeks. Knowing the range of aircraft can allow distinctions between heavy bombers, medium bombers and fighter bombers.

Third, although bomber payload is hard to determine by NTMs because it is a function of aircraft range, nominal range-payload values can probably be calculated with moderate confidence if estimates are made of the plane's structural and aerodynamic characteristics. However, this may not provide adequate verification since there may be different assumptions about mission characteristics.

Fourth, identification of nuclear capable fighter bombers is possible with low confidence only. Possible characteristics to observe include: special communication, command and control links associated with nuclear release; hardening to allow operations in a nuclear environment; and an alert capability usually associated with US nuclear strike aircraft.

Cruise missiles are more difficult to monitor. Table 6-1 (p.117) identifies the confidence associated with monitoring schemes for long-range cruise missiles. In general, largely because of the small size of cruise missiles and ease of concealment, cruise missile characteristics and activities can be monitored with moderate confidence. Any deliberate attempt to conceal cruise missiles will reduce confidence to a low level. Measuring inventories of cruise missiles and distinguishing between nuclear and conventional cruise missiles can be done with low confidence only, but cruise missile range can be estimated with moderate confidence by observing missile volume (in the absence of concealment measures). Cruise missile tests are difficult to detect because of a low flight path and the short distance for transmitting telemetry to an accompanying airplane. Guidance technologies would be difficult to monitor unless active radar sounding is used to provide terrain contour matching (TERCOM) maps of the opponent's territory. Production would be difficult to monitor because of the small size of the missiles. Monitoring the deployment of cruise missiles by observing launch platforms is possible, but many launch platforms serve dual purposes and there are likely few observable differences between conventional and nuclear launchers. Cruise missile activity could probably be inferred by identifying associated equipment or handling procedures (for nuclear warheads, for example), but this would yield only low confidence.

Another method, beyond NTMs, for monitoring cruise missiles is on-site on-demand inspections. "External" inspections which permit inspection of questionable locations or launch platforms but prohibit boarding any aircraft, submarine or surface ship and entering any sensitive facility, would probably not be useful since cruise missiles could be stored out-of-sight. "Internal" inspections of any suspected cruise missile site would create high confidence if a large number of such inspections were allowed, but political opposition to inspections would be formidable.

Monitoring is distinct from verification because it involves observation and identification of objects and activities only whereas verification involves a judgment about whether an opponent's activities violate a treaty. Lower degrees of monitoring confidence usually lead to a decline in the chances for adequate verification, but broader political and military considerations may provide compensation. For example, covert aircraft deployments would probably not increase Soviet first-strike capability and deployment of nuclear cruise missiles among conventional missiles would not necessarily yield any offensive advantage. If cruise missiles are deployed in large numbers as a new strategic reserve force, then adequate verification is more readily achieved because small violations decrease in significance.

Proposal Abstract J108(G79)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable materials "cutoff"

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Union of Soviet Socialist Republics. CD/PV.38, 3 July 1979.

4. **Summary:**
   Observance of commitments to cease production and eliminate nuclear weapons calls for extremely effective verification. This can be based on the use of national means of verification supplemented by well-thought out international procedures. Since measures aimed at halting the production of nuclear weapons and eliminating them will be complex and consists of a number of stages, the form and conditions of such verification must correspond to the objective extent and scope of the measures implemented in each stage.

 J109(A80)

Proposal Abstract J109(A80)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material "cutoff"

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   - IAEA safeguards
   (c) Complaints procedure - consultative commission

3. **Source:**
   Epstein, William, "A Ban on the Production of Fissionable Material for Weapons". Scientific American 243, no. 1 (July 1980): 43-51.

4. **Summary:**

The author contends that given the progress made in the past two decades in satellite surveillance and other national technical means, verification of a ban on production of fissionable materials for nuclear weapons no longer presents the same problems in terms of both effectiveness and intrusiveness as was true during the sixties. Modern verification techniques would ensure that large facilities needed to produce significant quantities of enriched uranium and plutonium could not escape detection. Secret diversion of fissionable material to clandestine facilities for production of nuclear weapons would not create any serious instability in the nuclear balance between the superpowers given the magnitude of existing American and Russian stockpiles. Hence, the verification system need not be 100 percent reliable to be effective.

Special attention concerning verification would have to be given to plutonium production particularly if the world moves towards a plutonium economy involving widespread use of plutonium and breeder reactors for the generation of electricity.

One solution to this verification problem would be to stop the move toward a plutonium economy. A more feasible approach would be to place all plutonium under IAEA safeguards and all plutonium stockpiles in IAEA custody. This would require strengthening of IAEA safeguards and establishment of special stockpiling facilities. Similar safeguards would be needed for highly enriched uranium produced for special non-explosive purposes. Full use would also be made of national technical means of verification and of consultative commissions to deal with ambiguous situations.

Agreement on a successful verification system in the context of a "cutoff" could lead to significant reduction in tensions between the US and the USSR and would provide a demonstration of international verification useful in other arms control contexts. Once production

of fissionable materials for weapons was stopped, future production of this material would only be for peaceful civilian purposes. This development would make it possible for the nuclear-weapons states to accept the same IAEA safeguards required of non-nuclear-weapons states under the Non-Proliferation Treaty, since there would be few military secrets to protect. If this occurs, it would remove one of the irritating features of the NPT for many non-nuclear weapons states - i.e. discrimination in the application of safeguards. Special precautions would need to be taken to prevent secrets about uranium enrichment from being disclosed but these need not be much different from present IAEA precautions to prevent disclosure of the technical and commercial secrets of peaceful nuclear facilities. "If additional verification procedures were required to ensure that uranium-enrichment and plutonium-reprocessing plants in the nuclear-weapons states were not being used to produce fissionable material for nuclear weapons, these procedures would be a necessary concomitant of the great nuclear capabilities of the nuclear-weapons states and would not detract from the essential equity of the treaty, as long as the safeguards on the nuclear weapons states were no less thorough of effective than those on the non-nuclear weapons states" (p. 49).

Proposal Abstract J110(A84)

1. **Arms Control Problem:**
   Nuclear weapons - fissionable material "cutoff".

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) On-site inspection - selective
   - IAEA safeguards
   (c) Short-range sensors - monitoring devices
   (d) Complaints procedure - consultation and cooperation
   - consultative commission

3. **Source:**
   Sharp, Jane M.O. "Exploring the Feasibility of a Ban on Warhead Production". In The Nuclear Weapons Freeze and Arms Control, pp. 30-37. Edited by Steven E. Miller. Cambridge, Mass.: Ballinger, 1984.

4. **Summary:**

Sharp argues that a ban on the further production of nuclear warheads would not be difficult to negotiate since it would involve only a handful of facilities and could be adequately verified by national technical means. Such a ban would necessitate the closure of a few facilities in the United States and Soviet Union which produce weapons-grade plutonium and tritium. Under a tacitly agreed moratorium on production pending a formal agreement, these facilities could be placed under "some kind of caretaker arrangement" (p.32) and the cessation of activity could be verified by existing national technical means including satellite-based cameras and infra-red sensors.

A long-term warhead production ban would require supplementary verification measures. IAEA inspection of civilian nuclear plants in the Soviet Union and United States would be necessary to ensure that fissionable material was not being diverted from nuclear power plants to use in weapons production. It would also be necessary to verify that fissile material for permitted uses (warhead replacement and enriched uranium for naval and research reactors) was not being directed to clandestine production of warheads. Analysts disagree over whether the IAEA safeguards regime would be adequate for this task, but it appears that it would. An expanded safeguards budget would permit upgrading of inspection teams and new technology could facilitate the task. In particular, new tamper-proof monitoring devices (RECOVER), which provide remote continuous on-site verification could ensure that small plutonium isotope separation facilities were not being used for covert production of small amounts of weapons-grade plutonium.

Both the United States and Soviet Union would likely resist intrusive on-site inspection measures for a bilateral freeze, but Soviet cooperation in monitoring a ban would be politically desirable to reassure American legislators and to deter cheating. The Soviets have lately become more open with military data and more cooperative in monitoring agreements, which suggests a positive trend. In June 1982, the Soviet Union announced that it would agree to open up civilian nuclear plants to IAEA safeguards. Consultation and cooperation procedures could be furthered by establishing a consultative mechanism similar to the Standing Consultative Commission (SCC) created by the SALT I Agreement (see abstract J67(T72)) or even expanding the mandate of the SCC.

National governments may wish to conduct routine inspections of weapons in their own stockpiles and this could pose a problem for verification of the cessation of activity at facilities producing nuclear components. A moratorium on activity would require the cessation of maintenance checks also, but this would not create a major security risk since this activity apparently consists of limited spot checks only. Another verification problem would be created by an agreement which allowed the replacement of warheads, but the replacement issue could be avoided by designing a production freeze in stages of limited duration and rapidly following this with negotiations on weapons reductions.

 J111(A61)

Proposal Abstract J111(A61)

1. **Arms Control Problem:**
   Nuclear weapons - missile tests

2. **Verification Type:**
   Remote sensors - radar
   - aerial
   - satellite

3. **Source:**
   Wiesner, J.B. "Inspection for Disarmament". In Arms Control: Issues for the Public, p.p. 131-132. Edited by L. Henkin, Englewood Cliffs, New Jersey: Prentice-Hall, 1961.

4. **Summary:**
   This proposal calls for the use of remote sensing to monitor a missile test ban. The suggested sensors would include the following:
   (1) ground-based conventional radar,
   (2) ground-based high frequency radar,
   (3) airborne infra-red detection,
   (4) acoustic detection,
   (5) detection of fuel products,
   (6) radio beacons or transponders on authorized vehicles, and
   (7) satellite-based infra-red detection.

Proposal Abstract J112(A62)

1. **Arms Control Problem:**
   Nuclear weapons - missile tests

2. **Verification Type:**
   (a) Remote sensors - radar
   (b) On-site inspection - selective

3. **Source:**
   Fletcher, J. "Some Problems Involved in a Missile Test Ban". In Woods Hole Summer Study, Verification and Response in Disarmament Agreements, Annex, Volume I, Appendix G. pp. 75-78. Washington, D.C.: Institute for Defence Analysis, November 1962.

4. **Summary:**

   This proposal deals with a possible agreement that would;
   (1) prohibit missile test flights with a range greater than two hundred nautical miles;
   (2) require prior notice of four weeks for flight tests of space vehicle and confirmation on the day before the flight; and
   (3) require that states conducting space launchings permit other states to attend the launchings.

   The right to inspect payloads and boosters would not be granted.

   The verification procedures suggested include the establishment of radar monitoring stations on the territory of all states engaged in flight tests of missiles or space vehicles. It is suggested that somewhere between 15 and 150 stations would be required depending on the coverage desired.

   Alternatively, it is suggested that all missile launch facilities could be monitored by inspectors permanently stationed at these facilities.

J113(A62)

Proposal Abstract J113(A62)

1. **Arms Control Problem:**
   Nuclear weapons - missile tests

2. **Verification Type:**
   (a) Remote sensors - radar
   (b) On-site inspection - selective

3. **Source:**
   Woods Hole Summer Study. Verification and Response in Disarmament Agreements, Annex, Vol. I. Washington, D.C.: Institute for Defence Analysis, November 1962.

4. **Summary:**

   This proposal suggests that a missile test ban would act as a brake on R & D programs insofar as such a ban would place severe limits on the confidence a military establishment could have in new missile systems.

   It is proposed that existing radar facilities could be used to verify compliance with a ban and that only a small number of detection stations would need to be established on the territory of states party to the agreement in order to verify that short-range tests (200 miles or less) are not being conducted. Observation of missile test sites could also be carried out by a small number of on-site inspectors. Finally, covert intelligence would be used to uncover plans for clandestine tests.

   The authors note that while this system would be unable to provide reliable information about penetration aids and guidance systems, it could provide accurate data about the overall behaviour of missile systems.

Proposal Abstract J114(A72)

1. **Arms Control Problem:**
   Nuclear weapons - missile tests
   - reentry vehicles

2. **Verification Type:**
   Remote sensors - radar
   - satellite
   - shipboard

3. **Source:**
   Greenwood, T. Reconnaissance, Surveillance and Arms Control, Adelphi Papers no. 88. London: International Institute of Strategic Studies, 1972, pp. 15-22.

4. **Summary:**

   Greenwood commences with a discussion of methods presently used by the United States to monitor Soviet and Chinese missile tests. These include:

   (1) Line-of-sight radar: These comprise installations in Turkey and the Pacific area as well as the BMEWS radars in Greenland and Alaska. They provide the information on the following:
   (a) the existence of a test, unless it is arranged so as not to come within range of any radars or unless there is a mechanical failure,
   (b) the missile's trajectory and hence range and impact area, and
   (c) some characteristics of the missile and reentry vehicle, like size and shape.

   On the basis of these data, second order information can be deduced. "For example, the type of missile or reentry vehicle may be determinable from the radar echo and thus it might be possible to judge when a new missile system is being tested. From the frequency of the tests, the progression of such a new system through its development, test and deployment cycle might be monitored" (p. 16)

   (2) Over-the-horizon (OTH) radar: By reflecting off the ionosphere OTH radar can achieve long-ranges. There are two types: back-scatter OTH which can determine the velocity and acceleration of a missile, and forward scatter OTH which can identify a missile by its exhaust signature.

   (3) Satellite systems: As is the case for OTH radars, satellite systems which can detect and tract missiles were developed primarily to provide early warning of a missile attack. The main sensors employed for this task are infra-red telescopes and television. Newer satellites have the capability of real time monitoring of tests.

(4) Shipboard sensors: These provide detailed information about the reentry vehicles, its manoeuvrability and the missile's accuracy.

Greenwood continues by assessing the utility of these systems for verifying restrictions on qualitative improvements in ballistic missiles. He suggests, first, that to discourage development of new missile systems incorporating improvements in accuracy or reentry vehicle design, an overall limit could be imposed on the number of tests in a given period of time. The rationale for this is that if the upper limit on the number of tests were small enough, new systems could not be developed. Verifying of such a ban would be easier if the agreement included "a prescription that all long-range missiles be tested along designated flight paths and or only at pre-announced times" (p. 20). However, such a prescription is not absolutely necessary for a limitation on the absolute numbers of tests. It would be a more important element for the less restrictive limitations on qualitative improvements discussed below. Existing American technical capabilities such as line-of-sight radar, OTH radar and early warning satellites "would permit, with a high degree of confidence verification of an agreement limiting the number of missile tests". (p.20). But could the USSR circumvent the aim behind a numerical limitation on tests by foregoing maintenance testing of existing missiles and concentrating only on testing of new technology? To answer this Greenwood examines American capabilities to monitor qualitative improvements during missile tests. He concludes that "with current capabilities, hardware different from that which had already been tested could probably be recognized as such" (p. 21). The introduction of new boosters could be verified with high confidence as could any appreciable change in the structure, size or weight of the reentry vehicle.

Less restrictive limitations than the above might also be considered. A ban on terminal manoeuvring and terminal guidance of reentry vehicles could probably be verified by existing technology. Restrictions on improvements in accuracy would be more difficult to verify since information on this characteristic must derive from second order inference. "Such a restriction could, however, be imposed indirectly by prohibiting terminal manoeuvring and by imposing limits on the ballistic coefficient of reentry vehicles" (p. 22), both of which could be verified adequately. Even better would be a total prohibition on new reentry vehicles.

A complete ban on multiple warhead tests could be verified by shipboard and perhaps other sensors, as well as the new early warning satellite system, when it is operational. However, it is not possible to effectively distinguish the development of a MRV capability from the development of a MIRV capability, and consequently, any limitation based on this distinction cannot be verified.

Proposal Abstract J115(A80)

1. **Arms Control Problem:**
Nuclear weapons - missile tests

2. **Verification Type:**
Remote sensors - aerial
- ELINT
- ground-based
- satellite
- shipboard

3. **Source:**
Scoville, Herbert Jr. "Verification of Soviet Strategic Missile Tests". In Verification and SALT: The Challenge of Strategic Deception, pp. 163-176. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.
See also: - "SALT Verification and Iran". Arms Control Today 9, no. 2 (February 1979).

4. **Summary:**
Scoville contends that during the test phase it is possible to obtain much detailed data on the nature of a new weapons system which might be concealed once it is deployed. There is, furthermore, a correlation between deployment and testing because strategic systems require extensive tests in a near operational configuration and conditions to acquire a reliable capability. The author reviews Soviet missile test sites and American resources for monitoring these sites.

Observations of Soviet missile tests are essential to verifying SALT II. The ABM, SALT I and SALT II Treaties all have provisions designed to assist verification. A summary of the more important provisions of this nature in SALT II is provided.

Scoville next assesses the US capability to monitor various provisions in the ABM and SALT II Treaties. He concludes that with a combination of available systems, the US can be confident that no undetected Soviet violation could significantly affect American security, in spite of the loss of intelligence collection sites in Iran.

J116(A79)

Proposal Abstract J116(A79)

1. **Arms Control Problem:**
   Nuclear weapons - mobile ballistic missiles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Drell, Sidney. "SUM". Arms Control Today 9, no. 9 (September 1979): 1-3.

4. **Summary:**
The author proposes the use of a Shallow Underwater Mobile (SUM) basing scheme for the American MX missile. This would involve carrying the missiles on small conventionally powered submarines which would operate within several hundred miles of the US coasts.

Verifying SUM would simply involve an extension of procedures presently used to check SLBM deployment. This contrasts with the verification difficulties of the Horizontal Dash basing mode for the MX. In the latter configuration there is a conflict between maintaining security of the system and verifying the actual numbers of deployed missiles. Resolving this conflict using NTMs will require considerable cooperation between the two superpowers. At the least, there will need to be agreement on special procedures and locations for introducing only one missile on each track.

Proposal Abstract J117(A79)

1. **Arms Control Problem:**
   Nuclear weapons - mobile ballistic missiles

2. **Verification Type:**
   (a) Remote sensors - satellites
   (b) On-site inspection - selective
   (c) Short-range sensors - monitoring devices

3. **Source:**
   Meyer, Stephen M. "Verification and the ICBM Shell-Game". International Security 4, no. 2 (Fall 1979): 40-68.
   See also: - "MAPS for the MX Missile". Bulletin of the Atomic Scientists (June 1979): 26-29.

4. **Summary:**

The focus of these articles is on the verification difficulties raised by deployment of mobile land-based missiles in a Multiple Protective Structure (MPS) basing scheme. The objective of such a basing system is to increase the number of points which an adversary must target by constructing numerous extra missile silos or shelters ("aim points"), all of which could house ICBMs but only a few of which actually would. The key to the success of such a system is that the opponent be unaware of which shelters house the missiles at any particular time, forcing him to target all of them.

For the purposes of his examination, Meyer uses the following hypothetical case: an MPS system of 250 squadrons, each squadron having 20 protective structures, one ICBM in each canister launcher, one transporter emplacer vehicle, 19 simulator packages and a service-support area. Each squadron would be located in an area of 20-60 square miles. According to the author, a different method of multiple basing such as a trench shuttle system will face verification problems similar to those of the above. For his analysis Meyer assumes that the USSR will follow the lead of the US in developing such an MPS system.

Using this case the author examines four basic approaches to verifying the number of ICBMs in a MPS configuration. The first method is monitoring the production of the special canister launcher to ensure that a significant number of extra launchers are not produced. Meyer concludes that such monitoring would require continuous observation which rules out non-stationary satellites. Geosynchronous satellites do not have the necessary resolution so they must be ruled out also. He suggests that on-site system (black-box technology and human visits) at production choke-points might be one way of verifying production, however this does not eliminate the possibility that undeclared production facilities could be built. He

raises two questions in this context: could such intrusive on-site verification be negotiated and would NTMs be capable of detecting undeclared facilities?

The second general verification approach is to monitor the production of the missiles to be used in the MPS system. This approach has problems similar to those concerning monitoring canister launcher production. In addition, however, in the case of Soviet MPS, Meyer contends that use of an undeclared production facility would be easier since the USSR has a number of missiles and missiles producing plants already. Secondly, the USSR has a large stockpile of mothballed ICBMs which in the future will include SS-16s, SS-18s and SS-19s. Could these through a combination of pre-planned engineering of canister launchers and retrofitting of stockpiled ICBM bodies be made compatible with an MPS system?

The third approach to monitoring an MPS system is verification of aspects of its support and operations activities. For example, if the encapsulation of each missile in its canister launcher is done at a single facility, this plant could be monitored to see how many combined ICBM/launchers emerged. But, as is true for monitoring production, the requirements of high resolution and continuous observation rule out NTMs and dictate the need for on-site verification. The transport of the ICBM/launchers to the MPS site might also be monitored, especially if transport schedules and destinations were provided. If the MPS system is designed so that there is only one entry point to each set of protective structures or 'field', such a choke point could be monitored. In this regard, NTMs would appear inadequate, dictating the use of on-site black-box technology at the entry point and around the perimeter of the MPS field.

Problems with this general approach to verification include the possibility of undeclared ICBM/launcher assembly plants, the requirement that the opponent design his MPS system to facilitate verification, and ensuring that the protective shelters do not have some rudimentary launch capability, independent of the canister-launcher.

The final verification approach is the most direct method. It involves sampling ICBM deployment in the MPS system by removing the blast covers on a fraction of the protective structures to allow photoreconnaissance satellites to count the number of ICBMs. Opening the blast covers on all the protective structures would be unacceptable since, for a critical period following such an inspection, the inspecting country would have target data which would permit it to destroy its opponent's missiles in a preemptive strike without diverting warheads onto the decoy shelters. Therefore a sampling approach is necessary. There is, however, a fundamental conflict in such a sampling approach: to be successful it should have a high probability of detecting significant cheating but at the same the information gained should not permit the opponent to break the MPS system's deception.

Meyer describes two sampling strategies: one involving a single pass by an observation satellite and the other involving a double pass. Using probability analysis, it is possible to calculate the minimum number of silos per squadron that would have to be inspected to achieve a specific probability of detecting a specific level of cheating.

A single pass inspection using large samples has technical and cost difficulties as well as the problem of reducing for a critical period the number of aim points at which an opponent must target his warheads. As Meyer points out in his Bulletin of the Atomic Scientists article, more verification is not necessarily better than less verification in a MPS environment. Efforts to achieve too high a level of verifiability will undermine the ability of the MPS to protect the land-based missiles.

More frequent but lower detection probability inspections could give a cumulative chance of detection equal to that for large samples. The party being inspected can also reduce the chance of disclosing MPS "cracking" information during the inspection by following certain procedures which Meyer describes.

In double pass inspections a preliminary examination is made of a small number of protective shelters in selected squadrons during the first pass. Based on the number of ICBMs observed, a second pass examines additional shelters in some of the same squadrons. Using this approach it is possible to reduce the total sample size. However, the techniques used for single pass inspection to reduce the possibility of disclosing information that would enable an adversary to crack the MPS system's deception, can not be applied for double pass verification.

For all these approaches to verifying an MPS system political questions arise over what constitutes adequate verification and over intrusiveness. In addition, any mobile launcher system involves the possibility that a mobile missile could be configured independent of a particular type of launch canister.

Meyer concludes that in terms of intrusiveness and the amount of adversary cooperation involved, verification in an MPS environment is without precedent in strategic arms control. The least demanding approach in this respect is the sampling one; yet even in this case NTMs are not useful unless active adversary cooperation can be guaranteed. In addition, there will be serious domestic political controversy over the verification system. Furthermore, the independent launcher concept inherent in an MPS system threatens to enhance break-out capabilities outside the MPS system. Finally, there is no reason to expect an opponent's system to be any more accommodating regarding verification than one's own.

In the Bulletin of the Atomic Scientists article, Meyer raises a few other points worth noting. He points to the difficulties raised by the possibility of false alarms due to technical limitations of NTMs. He also points to the necessity that a MPS system be linked to a verifiable ICBM limitations agreement if the system is to enhance the survivability of land-based ICBMs.

J118(A80)

Proposal Abstract J118(A80)

1. **Arms Control Problem:**
Nuclear weapons - mobile ballistic missiles

2. **Verification Type:**
(a) Remote sensors
(b) On-site inspection - selective

3. **Source:**
Davis, Paul K. "Land-Mobile ICBMs: Verification and Breakout". In Verification and SALT: The Challenge of Strategic Deception, pp. 143-162. Edited by William C. Potter. Boulder, Colorado: Westview Press, 1980.

4. **Summary:**

This paper attempts to discuss arms control problems associated with land-mobile ICBMs and with shell-game deployment systems in particular. Three verification problems are identified:
(1) Counting the number of ICBM launchers in overt ICBM deployment areas,
(2) Verifying the absence of ICBM launchers in areas other than overt ICBM deployment areas, and
(3) Coping with the possibility of "breakout".

Regarding the first problem, designs for shell-game systems are already constrained by SALT's provision preventing deliberate concealment measures which impede verification. However, there is no inherent contradiction between being able to count the other side's ICBM launchers and not being able to see them at all times, witness the counting of SLBM launchers. The proposed MX basing scheme will probably be verifiable for several reasons. First, the MX and its launcher will be built slowly and visibly near its deployment area. By constraints on production and access to the general areas, it will be possible to count the launchers with confidence using NTMs alone. In addition, it would be desirable to have provisions for sampling upon demand. The US could offer on-site inspection without requiring the Soviets to reciprocate providing that they satisfy US verification concerns if they deploy a similar shell-game system. Currently, however, the MX system is being designed for verification by NTMs.

Regarding the second verification problem, the author contends that it seems unlikely that the Soviets would try to cheat by deploying extra missiles in an overt deployment area. Instead, it is more appropriate to focus concern on small highly mobile missiles outside these areas.

Regarding the possibilities of "breakout", Davis briefly outlines several scenarios. In the context of the shell-game MX system there is a possibility of "covert breakout" (i.e. acquiring enough reentry

vehicles to neutralize that MX shell-game basing system) and "overt breakout" (i.e. the Soviets developing their own shell-game basing system which permits rapid expansion of their strategic force by filling up empty shelters if SALT II is abrogated). It is important that procedures for counting units prevent acquisition of reentry vehicles in excess of the numbers permitted and in excess of those counted in deciding how large the shell-game system should be. Shell game basing will create some unique breakout problems but their seriousness has been greatly exaggerated. Several hedges against both covert/overt breakout are discussed.

J119(A84)

Proposal Abstract J119(A84)

1. **Arms Control Problem:**
   Nuclear weapons - mobile ballistic missiles

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Sauerwein, Harry. "Mobile ICBM and Arms Control". In Nuclear Weapons Proliferation and Nuclear Risk, pp. 169-176. Edited by James Schear. London: Gower Publishing, 1984.

4. **Summary:**

This article considers the countability of mobile ICBMs as a method of verification of limits established by an arms control agreement. Various possible mobile systems considered by the US Air Force are examined. These include: a multiple protective structure (MPS) system; an air-mobile system; a truck-mobile system and an off-shore submersible system. Possible Soviet mobile ICBM systems are also considered.

Concealment of the production process obviously works against the use of national technical means for verification, but the design of the American mobile ICBM production process could aid verification. An open production and assembly process, such that launchers are countable as they are produced and assembled, would facilitate verification. A controlled rate of entry of launchers into the deployment area is also important so that they can be counted as they enter and exit the deployment area. Back-up sampling of deployed launchers in such a way that location uncertainty is not compromised could serve as an additional measure, but the Soviet Union would not likely agree to this cooperative verification method.

The Soviet Union might not use the same mobile system selected by the United States, but this will not pose problems for verification. The Soviets might attempt to minimize the openness of the production process, but if they adhere to SALT II prohibitions on deliberate concealment measures in designing, developing, producing, deploying and operating a mobile ICBM system, then "the US should be satisfied" (p.175). Verification of a Soviet liquid propellant missile would be more difficult than for a solid propellant missile because the reduction in weight would permit covert transfer into MPS areas by helicopter at night or under the cover of weather. It might therefore be desirable to ban liquid propellant missiles from an MPS basing system.

The risk of a "break-out" with quickly deployed excess mobile ICBM systems should be guarded against by research and development "hedge" programs which would allow a quick reaction by the United States.

Proposal Abstract J119.1(A83)

1. **Arms Control Problem:**
   Nuclear weapons - mobile ballistic missiles

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) On-site inspection - selective

3. **Source:**
   Finch, Louis C. "Verification of Arms Control Limits on Land-Mobile ICBM Launchers". Reproduced in Congressional Record (7 April 1983): E1424.

4. **Summary:**

Adequate verification of limits on land-mobile ICBM launchers depends in part on how these launchers are based. Two basing methods are discussed: unrestricted operating areas and restricted operating areas.

Under the first basing method wide dispersion of launchers makes it difficult for an enemy to locate and attack the launchers and the operating area would be too large to permit an effective barrage attack. Launchers could therefore be "soft" and less conspicuous. Verification by national technical means (NTM) would be difficult for two reasons. First, the areas are too large to permit complete coverage at one time. Counting would therefore have to be done by sampling parts of the whole area which might involve large estimation errors. Second, the large areas involved would likely contain many structures capable of hiding small ICBM launchers from satellites. NTMs would therefore be inadequate for verification. Other verification means might involve posting on-site inspectors at production plants to count the number of launchers produced. There would also have to be confidence that no secret production facilities exist.

In the case of restricted operating areas, the launchers themselves would likely be "hardened" against attack and therefore more conspicuous. If operating areas could be limited while maintaining ICBM survivability, a complementary arms control regime might be negotiated with the following elements to assist verification:

(1) Each side would have to declare the specific boundaries of the operating areas for their mobile launchers.
(2) Within these designated areas, the only buildings allowed which could contain the launchers would be the designated garages for the launchers.
(3) Each designated garage would have a sliding roof which would be opened at agreed times to permit satellite verification.

(4) Launchers, when outside their garage, would be prohibited from operating in ways to avoid satellite detection such as parking in dense forests.

(5) Final assembly of launchers would occur within the designated areas thus leaving no reason for a launcher to be outside the designated area.

(6) Launchers would have functionally related observable differences (FRODs) to distinguish them from vehicles found outside the designated areas.

The above regime would allow NTMs to be concentrated on limited areas and make activities in the areas less ambiguous, thereby improving verification. The main concern remaining would be whether it could be determined that no launchers were kept outside the designated area. However, it seems likely that the US could detect at least one violation if the Soviets kept many launchers outside the designated area.

J120(T63)

Proposal Abstract J120(T63)

1. **Arms Control Problem:**
   Nuclear weapons - partial test ban

2. **Verification Type:**
   Remote sensors - satellite
   - ground-based
   - sampling

3. **Source:**
   Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and Under Water. (The Limited Test Ban Treaty).
   Concluded: 5 August 1963.
   Signed by Canada: 8 August 1963.
   Entered into force for Canada: 28 January 1964.
   Number of parties as of 31 December 1979: 115.

4. **Summary:**
   No verification provision is explicitly included in the Treaty. It is implicit that national means are to be used. These techniques mainly involve surveillance by satellite, air sampling at ground stations to detect radioactive fallout, and other ground-based sensors.*

5. **Selected Comments of States:**
   In CD/PV.97 (5 August 1980) Sweden referred to the fact that current CTB Treaty negotiations had concentrated entirely on verification of underground nuclear explosions. Since the Limited Test Ban Treaty contains no express verification procedures, Sweden suggested it might be appropriate to consider international verification arrangements for atmospheric explosions as part of a CTB Treaty.

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* See Stockholm International Peace Research Institute. Yearbook of Armaments and Disarmament: 1972, Stockholm Almqvist and Wiksell, 1973, pp. 453-55.

J121(G84)

Proposal Abstract J121(G84)

1. **Arms Control Problem:**
   Nuclear weapons - partial test ban

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   United States. Department of Energy. Sandia National Laboratories. "Satellite Instruments for Monitoring the Limited Test Ban Treaty". Sandia Technology 8, no. 2 (November 1984): 8-11.

4. **Summary:**

This article describes Sandia Laboratories' work on instruments to aid verification of the Limited Test Ban Treaty (LTBT, 1963). Verification of the LTBT requires continuous monitoring of the earth's surface, its atmosphere and many parts of space. Monitoring instruments flown on satellites can detect direct radiation from nuclear detonations in space: x-rays, gamma rays, neutrons, charged particles and fission products. Sandia Laboratories developed the electronic logic system and other subsystems for these instruments as well as optical (visible-light) detectors for atmospheric burst monitoring. The electronic logic system identifies and rejects false signals by testing characteristics of (potential) explosions such as rise-time and intensity of the flash pulse duration and possible signal coincidences from several detectors. Information is then transmitted to and analysed by ground-based computers and personnel.

These instruments were mounted on satellites of the American Vela Hotel program which involved six satellites launched between 1963 and 1970. Currently, Sandia is developing nuclear explosion monitoring instruments for Global Position System satellites.

Proposal Abstract J122(A85)

1. **Arms Control Problem:**
   (a) Nuclear weapons - partial test ban
   - comprehensive test ban
   - peaceful nuclear explosions
   - ballistic missiles
   - cruise missiles
   - manned aircraft
   - missile tests
   - mobile ballistic missiles
   - reentry vehicles
   - anti-ballistic missiles

   (b) Regional arms control - outer space
   - sea bed

2. **Verification Type:**
   (a) Remote sensors - satellite
   - ground-based
   - aerial
   - shipboard
   - radar
   - ELINT
   - sampling

   (c) Seismic sensors - intra-border stations
   - extra-border stations

3. **Source:**
   Richelson, Jeffrey. "Technical Collection and Arms Control". In Verification and Arms Control, pp. 169-216. Edited by William C. Potter. Lexington, Mass.: D.C. Heath and Company, 1985.

4. **Summary:**
This article describes and evaluates American national technical means which are used to collect intelligence concerning all aspects of strategic arms programs which may be relevant to US participation in arms control agreements. Richelson argues that "although certain technical collection activities are of little or no relevance to the monitoring of an agreement, it can be legitimately claimed that all collection relevant to the strategic capabilities of the nation constrained by the agreement is relevant" (pp. 204-205). Five methods of technical collection are discussed: photographic reconnaissance/ imaging, signals intelligence, ocean surveillance, space surveillance and nuclear monitoring. These technologies are relevant to the following treaties or agreements: the Limited Test Ban Treaty (see abstract J120(T63)); the Outer Space Treaty (see abstract B24(T67)); the Sea Bed Treaty (see abstract B30(T71)); the ABM Treaty (see abstract J67(T72)); the Threshold Test Ban Treaty (see abstract

K54(T74); the Peaceful Nuclear Explosions Treaty (see abstract C52(T76)); and the SALT II Treaty (see abstract J79(T79)). The technical collection systems are also relevant to the proposals for a nuclear freeze, a comprehensive test ban, and a treaty banning or limiting anti-satellite (ASAT) weapons.

Imaging/Photographic Reconnaissance:

Imaging satellites can be used to identify mobile and fixed ICBM launchers, submarine ballistic missile launchers and aircraft, to identify modifications in length, diameter or volume of these systems, and to detect activity at test sites or production facilities. Provisions of the LTBT, the ABM Treaty and the SALT II Treaty can all be directly monitored by imaging satellites.

The American Big Bird satellite (KH-9) was thought to possess both close-look and area surveillance cameras in addition to infra-red and multispectral scanners, but the most recent reports describe it as purely an area surveillance satellite. The oldest US imaging satellite presently in operation, the KH-8, possesses the greatest resolution capability. Table 10-1(p.174) displays the resolution required for detection and interpretation tasks.

The new KH-11 satellites transmit pictures in real-time and have a longer life than the Big Bird satellites. Even though the KH-11 has inferior resolution powers than close-look satellites, it will replace these satellites and the Big Bird systems. Press reports suggest that the KH-11 discovered that the USSR was constructing a new super-submarine and a new mini-aircraft carrier. The KH-11 also disproved reports of a Soviet chemical weapons facility by showing that it was in fact a reserve arms storage facility. Currently, work is proceeding on the KH-12, a follow-on satellite to the KH-11 with resolution powers equal to those of the present close-look satellite. An imaging radar satellite which can penetrate cloud cover is also planned.

Aircraft reconnaissance systems supplement satellite coverage and, unlike satellites, can be dispatched quickly to particular areas. The SR-71 is a plane that can film 60,000 square miles in one hour. It is equipped with a radar detector and electronic countermeasures. Its three dimensional filming equipment can produce resolution sufficient to locate a mailbox on a country road. It is reportedly also fitted with a synthetic-aperture radar for high altitude night imaging. An SR-71 photographed the entire first Chinese nuclear test. The U-2R (the present version of the U-2) is also used for reconnaissance purposes, but has largely been supplanted by the SR-71.

Signals Intelligence:

Signals intelligence (SIGINT) includes communications intelligence (COMINT) and electronic intelligence (ELINT). Subcategories of ELINT include radar intelligence (RADINT), telemetry intelligence (TELINT) and foreign instrumentation signals intelligence (FISINT). Signals intelligence is used to monitor Soviet compliance with the ABM and SALT II treaties.

Satellites, aircraft, ships, submarines and ground facilities are all used to collect SIGINT. The high orbiting Rhyolite satellite possesses considerable signal intercepting abilities and is used for arms control monitoring. It can be targeted against telemetry, radars and communications, but its highest priority is telemetry interception. Other SIGINT satellites, low orbiting ferret satellites and aircraft also provide SIGINT information. Both the SR-71 and U-2 aircraft have SIGINT as well as photographic capabilities.

Radars and antennas at various ground sites are an important part of the SIGINT collection network. The COBRA DANE phased array radar is stationed in the Aleutian Islands, 480 miles from the Kamchatka Peninsula which is the primary impact point for almost all Soviet missile tests. COBRA DANE can detect an object the size of a basketball at a range of 20,000 miles and can simultaneously track more than a hundred objects. It is thus able to track Soviet reentry vehicles during ICBM tests and to track satellites. Other radar centres assist COBRA DANE.

Naval vessels, both surface vessels and submarines, are also used to collect signals intelligence.

Ocean Surveillance:

The Ocean Surveillance Information System consists of a variety of collection systems: satellites, aircraft, ground stations, surface ships and undersea collection systems. White Cloud, the satellite portion of the Classic Wizard Ocean Surveillance system, lacks a radar capability, but is equipped with a passive infra-red scanner, radiometers and radio-frequency antennas which can monitor radio communications and radar emissions from Soviet submarines and ships.

Space Surveillance:

Space surveillance systems assist in monitoring compliance with the Outer Space Treaty, the ABM Treaty and the SALT II Treaty. They also provide intelligence on Soviet space systems and their contribution to Soviet military capabilities. An ASAT Treaty could be monitored through detection and tracking of Soviet satellites.

The KH-11 satellite appears to have the ability to photograph Soviet satellites in low earth orbit. Research on space-based reconnaissance systems is proceeding and an infra-red system for detecting hostile satellites has been successfully tested on the ground. The Air Force's Space Surveillance Technology Program is designed to develop a space-based system with full earth orbit coverage to reduce overseas basing of sensors and to provide real-time coverage.

The ground-based Space Detection and Tracking System (SPADATS) relies on a series of Baker-Nunn optical cameras. These cameras can photograph at night an illuminated object the size of a basketball a distance of 20,000 miles or more in space. However, the cameras are effective only when the weather is clear and the satellites are illuminated by the sun. The system is useful for tracking but not detection and has a slow data acquisition rate and film processing time. The Ground-based Electro-Optical Deep Space Surveillance (GEODSS) system will soon replace the Baker-Nunn system. The

advantage of this system is its ability to provide real-time data with a computer-managed instantaneous video display of surveillance data, but it is still dependent on clear weather and illumination of satellites. Its memory will be able to alert the user to the discovery of new space objects. Other SPADATS sensors include those of the Naval Space Surveillance System and electro-optical sensors. A Pacific Radar Barrier (PACBAR) is planned and this system will be able to determine the orbit of a satellite within its first revolution. Other radar systems also assist in space surveillance.

Nuclear Detonation Monitoring:

Monitoring the nuclear detonation activities of other countries can provide intelligence related to compliance with the TTBT's 150 kiloton limit and the LTBT's prohibition of non-underground explosions. It can also provide information on nuclear weapon characteristics so that countermeasures can be developed. The American VELA program was designed to detect underground nuclear explosions, atmospheric and space detonations with ground-based monitors and space detonations with space-based detectors. The Vela Hotel satellite is the main component of the overall US nuclear detonation monitoring capability. These satellites carry x-ray, gamma ray and neutron sensors, optical and electromagnetic pulse sensors, background radiation counters and logic circuitry to discriminate between natural events and man-made radiation. Two other satellite systems, the Defense Support Program (DSP) Satellites and the NAVSTAR Global Positioning System (GPS), will take over nuclear detection monitoring as the VELA satellites come to the end of their life.

Aerial sampling is used to detect atomic particles released by a nuclear explosion. The HC-130 aircraft uses a seawater sampler to detect possible underwater nuclear tests.

Underground nuclear tests can be detected by seismic monitoring. At distances less than 625 miles from an event, detection methods can distinguish explosions greater than a few kilotons from earthquakes. Such distinctions are more difficult to make as distances become greater. Using several seismometers in an array can enhance the signal-to-noise ratio. The seismic arrays and seismometers operated by the Air Force Technical Applications Center are located at nineteen sites throughout the world. A Remote Seismic Test Network (RSTN) has been established by the US Department of Energy to evaluate possibilities for an "in-country" system to monitor a CTBT. The RSTN consists of five stations in the United States and Canada positioned about 2,000 kilometres apart (see abstract K56(A83)). Research is being conducted on an ocean-bottom seismic sensor system involving the deployment of seismometers in boreholes beneath the sea floor in international waters.

The Limitations of Technical Collection Systems:

The limited number of collection systems cannot provide complete 24 hour coverage of all targets of interest. Continuous monitoring of all points would require extensive processing operations and would be very costly. US plans to increase coverage by developing a KH-X satellite were abandoned because of excessive processing and analysis requirements. SIGINT systems also can monitor only a limited number of targets at any given time.

Photographic systems cannot penetrate darkness and cloud. Infra-red sensors permit night photography, but resolution capabilities are reduced significantly when this method is used. Frequent cloud cover over Eastern Europe and the Soviet Union prevents constant coverage.

SIGINT systems often lose some effectiveness because of their high altitudes. Satellites at geosynchronous altitudes may be unable to pick-up signals which are significantly weaker than those on the ground and they may be unable to pick up any signals during the initial boost phase of missile launches. Intercepted encrypted telemetry is of no use.

There are considerable uncertainties in calculating the yield of nuclear explosions because of variations in geologic characteristics. Seismic decoupling can alter the measured yield of an explosion by a factor of ten. There is also regional variation in the amount of attenuation seismic waves experience as they pass through the upper mantle of the earth. It is therefore difficult to evaluate charges of Soviet non-compliance. A detonation with an estimated yield of 120 kilotons might in fact have an actual yield of between 60 and 240 kilotons. One classified study found that seismically measured yields of Soviet weapons indicated observance of the 150 kiloton limit, but that the distribution of actual yields indicated that some events were above 150 kilotons. Accusations of non-compliance have not been made because of these uncertainties, but these experiences suggest that seismic verification of a CTBT will not be able to provide absolute assurance of detection and identification of explosions below a significant threshold.

American collection systems must also deal with Soviet concealment and deception practices. Several reports suggest that the Soviet General staff has established a Chief Directorate of Strategic Deception to coordinate these activities.

Richelson argues that absolute verifiability of treaty provisions is not necessary. Uncertainty does not necessarily create risk and absolute verifiability itself may be insufficient. Emphasis on technical collection capabilities for verification neglects the necessity for gathering information on the entire range of Soviet military capabilities which is a requirement for proper evaluation of the potential impact of a treaty.

J122.1(A81)

Proposal Abstract J122.1(A81)

1. **Arms Control Problem:**
   Nuclear weapons - peaceful nuclear explosions

2. **Verification Type:**
   Remote sensors

3. **Source:**
   Kamegai, Minao. "Applying Computer Modeling to Verification". National Defense (November 1981): 38-40.

4. **Summary:**
   The paper outlines a model by which computer technology combined with "above ground monitoring" can estimate the yield of one kind of peaceful nuclear explosions (those which are underground and which vent to the atmosphere). The author suggests that his calculations also show that monitoring PNEs would be essential because the USSR could use similar computer models to "determine the optimum depth at which to explode a device so as to make gas venting most obscure and seismic coupling most inefficient" (p.40).

Proposal Abstract J123(A82)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation

2. **Verification Type:**
   Remote sensors - satellite

3. **Source:**
   Santhanam, K. "Use of Satellites in Crisis Monitoring". In Outer Space: A New Dimension of the Arms Race, pp. 265-274. Edited by Bhupendra Jasani. London: Taylor and Francis, 1982.

4. **Summary:**

This article examines the capabilities and effectiveness of military reconnaissance satellites. Space reconnaissance, the author maintains, can be viewed as an extension of aerial reconnaissance. Advances in launcher technology and payload stabilization systems have developed satellite reconnaissance to the point that photographs taken from space are as good as those taken from aircraft. Satellite photography is reportedly capable of ground resolution in the range 1 to 3 metres for area surveillance and of 0.3 metres for close-look satellites. This capability can yield information on 'functionally related observable differences' (FRODs) and 'externally observable design features' (EODFs) used in strategic arms limitation agreements such as SALT II (abstract J79(T79)). Area surveillance can provide precise or near-precise identification of most military targets and close-look imagery can permit target description and analysis.

Both space and aerial reconnaissance are limited in their ability to provide night-time coverage and to detect camouflage and deception techniques at a target site. However, infra-red coverage, radar imaging at lower resolutions and camouflage detection using the difference in spectral reflectance characteristics of foliage and paint can alleviate these problems somewhat. Satellites are also unable to determine military intent associated with military exercises so collecting other intelligence information is necessary before judgments can be made.

Neither the US nor the USSR has acknowledged the use of satellites for monitoring crises. It is assumed, however, that both countries have monitored all international crises in an effort to test and improve their image acquisition and interpretation systems. Soviet satellites may have covered the Sino-Soviet border conflict in 1969, the Indo-Pakistani crisis of 1971, the Arab-Israeli war in October 1973 and the subsequent ceasefire. Analysts have drawn inferences about crisis monitoring from ground track calculations based on published data from satellite tracking networks.

The author reports three "inferred" instances of satellite monitoring which are relevant to verification of arms control agreements. Analyses of the ground tracks of an American Big Bird satellite and two Russian Cosmos satellites launched in June and July 1977 suggest photographic coverage of the Kalahari desert in connection with a possible South African nuclear test. It has been inferred that the same satellites monitored the rocket-launching range of the West German firm, OTRAG, in the Shaba province in Zaire. A Big Bird satellite and a Cosmos satellite may also have observed the crater formed by India's peaceful nuclear explosion conducted on 18 May 1974.

Proposal Abstract J124(A83)

1. **Arms Control Problem:**
   Nuclear weapons - proliferation
   - fissionable materials "cut off"

2. **Verification Type:**
   (a) Remote sensors
   (b) International control organization
   (c) On-site inspection - selective

3. **Source:**
   Sharp, Jane M.O. "Verifying a Warhead Freeze". Arms Control Today 13, no. 5 (June 1983).

4. **Summary:**

This article examines the prospects for verifying a ban on the construction of warheads as a central component of a comprehensive nuclear freeze. In order to determine the feasibility of verifying such a ban, the author speculates on the nature of possible restrictions. The shut-down of some US nuclear facilities could be readily verified using only national technical means of verification. Where fissile material is still produced at a facility, an international agency such as the IAEA could ensure that this material would not be diverted to weapons production.

Another issue pertains to the difficulties arising from US insistence that adequate verification requirements precede any agreement. It is proposed that the US forego this requirement and "meet the Soviet Union half way", in the hope that this might in turn inspire Soviet concessions. The article concludes that such a ban might be verifiable, as plant shut-downs could be monitored through national technical means, which would in turn be supplemented by both cooperative measures and on-site inspection.

J125(A74)

Proposal Abstract J125(A74)

1. **Arms Control Problem:**
   Nuclear weapons - reentry vehicles
   - missile tests

2. **Verification Type:**
   (a) Remote sensors - satellite
   - shipboard
   - radar

   (b) Complaints procedure - consultative commission

3. **Source:**
   Scoville, H. "A Leap Forward in Verification". In SALT: The Moscow Agreements and Beyond, pp. 160-182. Edited by M. Willrich and J.B. Rhinelander. New York: The Free Press, 1974.

4. **Summary:**

The author suggests that a limitation on the number of tests of MIRVed missiles could be verified with a high level of assurance using national technical means, primarily satellite and shipboard photography as well as various radar systems. An agreement to restrict tests to existing test ranges would make this task simpler but would not be essential. Such an agreement would be important in monitoring tests of MIRVed SLBMs.

The author suggests that attempts to conceal MIRV testing under the guise of a space program would be difficult to prove unequivocally, but that sufficient doubt would be raised to call for an inquiry through the Standing Consultative Commission established under SALT I. Similarily, MIRV tests designed to have only one reentry vehicle enter the impact area would draw sufficient suspicion as a result of inconsistencies in mass characteristics to justify an inquiry.

Proposal Abstract J126(A78)

1. **Arms Control Problem:**
Nuclear weapons - reentry vehicles
- mobile ballistic missiles
- cruise missiles

2. **Verification Type:**
Remote sensors - aerial

3. **Source:**
Perry, R. "Verifying SALT in the 1980's". In The Future of Arms Control: Part I - Beyond SALT II, Adelphi Papers #141, pp. 15-24. Edited by C. Bertram. London: International Institute of Strategic Studies, 1978.

4. **Summary:**
The author contends that aerial verification is particularly promising though it has received little attention since the early 1960's. In the modern world of MIRV, land mobile ICBMs, cruise missiles and other strategic gadgetry, the approach has a number of attractions:

(1) It lacks some of the more intrusive aspects of on-site inspection since it can be conducted without exposing the military hardware of the host country to the close scrutiny of an inspector;
(2) It promises a prompt and direct view of a suspect activity;
(3) Concealment of any major weapons activity would be difficult because the reconnaissance aircraft need follow no set path or schedule and they are not necessarily inhibited from performing their assignment by night or bad weather; and
(4) It is comparatively cheap, which creates the possibility that many nations could participate without having to rely on the good will of one of the superpowers.

As the author envisages it, the reconnaissance aircraft would be permitted to fly freely over the territory of the inspected nation. The aircraft would have to be incapable of performing offensive missions, of carrying strategic weapons or of detracting from the defensive potential of the nation being reconnoitered. This could be accomplished by ensuring that only "pure" reconnaissance aircraft could be used or by permitting on-the-ground inspection of each aircraft at any time.

Proposal Abstract J127(A78)

1. **Arms Control Problem:**
Nuclear weapons - reentry vehicles
- missile tests

2. **Verification Type:**
(a) Remote sensors
(b) International exchange of information

3. **Source:**
Potter, William C. "Coping with MIRV in a MAD World". Journal of Conflict Resolution 22, no. 4 (December 1978): 599-626.

4. **Summary:**

The author argues that not all types of MIRVs are inherently destabilizing in terms of the strategic balance between the two superpowers. Specifically, MIRVed SLBMs may contribute to deterrence stability by increasing the number of warheads that would survive any first strike. On the other hand, several arguments can be made favouring a ban on MIRVed ICBMs.

Given this, Potter contends that the verification of a MIRV ban is not an insurmountable obstacle to agreement. It has been argued in the past that unless the MIRV program was halted before completion of its testing phase, there would be no feasible means of verifying a treaty concerning deployment limitations. The use of national technical means would not be sufficient to distinguish MIRVed and unMIRVed warheads according to this argument; it would be necessary to physically inspect the interior of a missile's reentry vehicle or examine it at close range with special instruments. Since neither of the superpowers is likely to agree to such on-site inspection both critics and supporters of MIRVs have tended to agree that a ban on MIRVs after they have been deployed is not likely.

The approach which US negotiators have adopted to circumvent the deployed MIRV verification problem is to assume that once any missile has been tested successfully in a MIRVed mode, all missiles of that type will be counted as MIRVed. There are several problems with this approach. First, it does not permit one to distinguish between missile launchers which are identical except that one launcher contains MIRVs and the other does not. For example, how is one to determine the number of submarines carrying MIRVed missiles if the Soviets develop a new MIRVed SLBM which is compatible with old launchers on existing submarines? Requiring that all launchers capable of firing a MIRVed missile be counted towards the MIRV limit is not realistic, according to Potter.

Another problem with the above "typing" approach is that its political feasibility derives in part from the high MIRV ceiling

tolerated. Because there is only limited advantage to be gained from cheating when MIRV levels are set so high, compliance with the limitation is encouraged.

Potter contends that a verifiable way to limit <u>deployed</u> MIRVs is a "confidence flight test quota". This approach relies for its effect upon the loss of confidence in the operational reliability of MIRVed missiles that would result from an agreement to halt or at least substantially reduce the number of annual flights tests of strategic missiles in a MIRVed mode. While this approach can be applied to all MIRVed missiles, Potter favours focussing the limitations upon MIRVed (and preferably MRVed) land-based ICBMs.

One of the main advantages of such a flight test quota is that is it not dependent upon a high MIRV ceiling (as the "typing" rule approach entails). In addition, it requires no technological improvements in reconnaissance capabilities. The task of verification could be reduced further if the flight test agreement also provided the tests of long-range missiles be pre-announced and conducted at specified test ranges.

One verification problem with such a flight test limitation concerns distinguishing MRV tests from MIRV tests. The obvious and desirable way to alleviate this difficulty is to include MRVs within the scope of the flight test ban. If this is not politically feasible, verification problems could be reduced by requiring that flight tests be preannounced and confined to agreed test paths thereby increasing the probability that the release stage of the reentry vehicles (when MRVs and MIRVs are most distinguishable) could be photographed.

 J128(G78)

Proposal Abstract J128(G78)

1. **Arms Control Problem:**
Nuclear weapons - research and development

2. **Verification Type:**
(a) Remote sensors - (Article 2(1))
(b) Complaints procedure - consultation and cooperation (Article 2(2)
- referral to the Security Council (Article 2(3) and (4))

3. **Source:**
Socialist States. "Draft convention on the prohibition of the production, stockpiling, deployment and use of nuclear neutron weapons". CCD/559, 10 March 1978.

4. **Summary:**
Article 2(1) provides a formula for the use of "national technical means of verification ... in a manner conforming to the ... rules of international law". Article 2(2) provides for consultation and cooperation concerning any problems. Such consultation may be undertaken "through appropriate international procedures within the framework of the United Nations". Furthermore, any party can lodge a complaint concerning suspected violations of the convention with the Security Council (Article 2(3)). Parties, furthermore are under an obligation to assist the Security Council in any investigation it initiates (Article 2(4)).

Proposal Abstract J129(A82)

1. **Arms Control Problem:**
   Nuclear weapons - research and development
   - comprehensive test ban
   - missile tests
   - cruise missiles
   - fissionable materials "cut off"

2. **Verification Type:**
   (a) Remote sensors - satellite
   - radar
   - ELINT
   (b) On-site inspection - selective
   - IAEA safeguards
   (c) Seismic sensors - intra-border stations
   (d) Short-range sensors - monitoring devices
   - seals

3. **Source:**
   Niedergang, Mark. "Verification of a Nuclear Weapons Freeze". <u>Bulletin of Peace Proposals</u> 13, no. 3, (1982).

4. **Summary:**

This article explores the verifiability of a nuclear freeze. It begins with an explanation of the concept of verification, and makes some basic assertions regarding the problems usually associated with verification. While challenges to the verifiability of a proposal should not be avoided, "one can assert with confidence that a freeze agreement could be made adequately verifiable" (p. 261). Past events show that verification is a stumbling block to agreement only where political will is absent.

Verification is a relative concept, so that the requisite level of verification which is deemed to be adequate will depend on certain criteria. An adequate verification technique will detect militarily significant treaty violations in a sufficiently timely manner to allow a nation to respond effectively. Arms control agreements are usually monitored through a combination of "national technical means" of verification and cooperative verification. National technical means gather data through spy satellites and listening posts which utilize photographic, infra-red, radar, radio and electronic sensors. They are unilateral, unlike cooperative means of verification which must be negotiated by both nations involved. Seismic installations, restrictions on concealment practices, on-site inspection and data exchange all require cooperative verification.

There is evidence that Soviet treaty compliance has been less than perfect. While the Soviet Union has not abrogated any legally binding arms control treaty, "they have tried to exploit ambiguities and have disregarded US views on the spirit of the accords" (p. 262). Such practices do not pose a serious threat however, and more substantial treaty violations would pose great risks of detection while providing only marginal gains. In order to conceal a new weapon, the Soviet Union would have to disguise all five stages of development; it is highly unlikely that the research, development, testing, production and deployment of a weapon could be concealed, and to attempt to do so would be very costly.

One potential obstacle to the verification of a nuclear freeze is perceived in the traditional Soviet rejection of on-site inspection. Most aspects of a nuclear freeze could be verified using other verification measures, but some parts of a freeze would 'clearly benefit' from on-site inspection. Despite the possible benefits, however, the acceptance of a nuclear freeze should not be predicated on the acceptance of on-site inspection; "it is important to ensure that the independently verifiable parts of the freeze should not be held hostage to those which are more difficult to verify without on-site inspection" (p. 263). Prospects for on-site inspection are improving however, with a 'softening' of the Soviet position, and the USSR has recently agreed to permit ten seismic stations on Russian soil. Finally, this willingness may be enhanced by the nature of the freeze proposal, as the Soviet Union has indicated that they would prefer a more comprehensive proposal.

The freeze proposal itself is quite extensive, and would affect the testing, production and deployment of nuclear warheads, weapon-grade material and nuclear delivery systems. Previous attempts to reach a comprehensive test ban agreement have been frustrated by the United States' insistence that Soviet concessions on seismic sensors and on-site inspection are not sufficient to allow adequate verification. "Yet the failure to conclude a Comprehensive Test Ban Treaty has little to do with verification and a great deal to do with the political power of the military in the US" (p. 263). National technical means of verification would suffice to monitor missile tests, with the possible exception of cruise missiles for which "independent verification of non-testing would be more difficult and less reliable, though still possible. This area needs further investigation to determine the adequacy of national technical means of verification" (p. 264).

The verifiability of a ban on production is one of the great contentious issues in negotiations for a nuclear freeze. Despite such controversy, production should not be excluded from a freeze, since a literal interpretation of such a treaty would permit continued production even where testing is banned. The task of verification is also made easier by a total ban on testing and production; "the comprehensiveness of the freeze proposal means that verification of the whole package would be significantly easier than verification of the separate parts. High-confidence verification of one link of the production chain could compensate for weaknesses in other links" (p. 264).

A ban on the production of weapons-grade fissionable material would be relatively easy to verify since a number of International Atomic Energy Agency (IAEA) safeguards are already in place. Tamper-proof cameras and seals allow a form of remote on-site verification as they monitor the movement of nuclear materials. Such verification would be further simplified by a nuclear freeze which would allow the closure of some nuclear plants. Furthermore, there are only three plants in the US which currently manufacture nuclear warheads, and any activity at these sites would be 'immediately suspect'. Finally, the production of nuclear missiles and aircraft could be monitored by satellite, since the size, known location and transportation routes of production plants would all facilitate the detection of suspicious activity.

Any deployment of a new weapons system would be readily monitored using national technical means of verification. Thus, a comprehensive nuclear freeze would significantly improve the effectiveness of verification by requiring only that any deployment be detected; it would not be necessary to distinguish the number or category of weapons being deployed. Again the deployment of cruise missiles would be somewhat more difficult to verify, but their platforms are more readily distinguished and are thus easier to monitor.

It is concluded that obstacles to a verifiable nuclear freeze tend to be political rather than technical in nature. Absolute certainty is impossible, and "a more reasonable approach is to weigh the risks of violation of a freeze against the risks of the alternative: an expensive and destabilizing nuclear arms race which will increase the likelihood of nuclear war" (p. 266).

J130(A83)

Proposal Abstract J130(A83)

1. **Arms Control Problem:**
   Nuclear weapons - research and development

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Paine, Christopher. "Freeze Verification: Time for a Fresh Approach". Bulletin of the Atomic Scientists 39 (January 1983): 6-9.

4. **Summary:**
   The author suggests that a freeze on all testing, production and deployment of nuclear weapons could be adequately verified. Large parts of a freeze could be verified by national technical means and those which could not are at least partially verifiable by cooperative measures including on-site inspections. The military significance of developments which escape detection would be marginal in comparison with existing arsenals. The Soviets would be deterred from cheating because detection would lead to renewal of the arms race and a confrontational atmosphere. Verification of the most significant aspects of the agreement with moderate to high confidence and with low to moderate confidence for the remaining provisions would be sufficient to deter Soviet cheating.

Proposal Abstract J131(A83)

1. **Arms Control Problem:**
Nuclear weapons - research and development
- missile tests
- ballistic missiles
- cruise missiles
- manned aircraft
- comprehensive test ban
- fissionable material "cutoff"

2. **Verification Type:**
(a) Remote sensors - satellite
- radar
(b) On-site inspection - selective
- IAEA safeguards
(c) Short-range sensors
(d) Seismic sensors - extra-border stations

3. **Source:**
Stares, Paul. "Can a Nuclear Freeze be Verified?" In The Nuclear Freeze Debate: Arms Control Issues for the 1980s, pp. 149-166. Edited by Paul M. Cole and William J. Taylor. Boulder, Colorado: Westview Press, 1983.

4. **Summary:**
The author argues that a "substantial part" of a freeze on the testing, production and further deployment of nuclear warheads, missiles, and other delivery systems could be verified by national technical means. In fact, the United States has the capability "perhaps enough to verify all of it to a 'satisfactory' level" (p. 153). A table produced by the Federation of American Scientists (p. 154) estimates high-moderate to high levels of confidence for monitoring tasks of a nuclear freeze with existing intelligence systems.

Deployment could be monitored by satellites such as the "Big Bird", KH-11 and close-look satellites operated by the CIA and the Air Force. Air and sea-based systems could supplement surveillance. These systems have difficulty, however, identifying dual-capable systems, multiple warheads on a single system and the range of existing weapons nor can they detect covert stockpiling of nuclear, capable systems and nuclear warheads. 'Functionally related observable differences' (FRODs) used in the SALT II agreement may alleviate the problem of identifying ambiguous weapons and differentiating between actual and potentially convertible nuclear systems. 'Externally observable design features' (EODFs) which are not necessarily related to the military function of the weapon system could also facilitate verification of a freeze.

Early warning satellites with infra-red sensors and 'ferret' satellites such as the Rhyolite series which can monitor flight test telemetry could monitor a prohibition on the flight testing of new or modified ballistic missiles. Sea- and land-based radio monitoring posts and observation radars located around the Soviet Union can provide coverage of Soviet missile ranges. It is not clear whether cruise missile tests can be monitored from outside the Soviet Union. A nuclear test freeze could be monitored by seismometers located around the Soviet Union assisted by early warning and reconnaissance satellites. In order to create confidence, mutually approved inspection teams could be permitted to investigate ambiguous activities.

Verification of a ban on the production of nuclear delivery systems, warheads and weapons grade nuclear material would be difficult. National technical means could probably not provide adequate verification and on-site inspection might also not be able to remove doubts. Tamper proof 'black boxes' with monitoring devices and IAEA safeguards for nuclear material production could increase the general level of confidence.

With regard to evaluating the level of confidence in verification, Stares relies on Defense Secretary Harold Brown's testimony during the SALT II Senate Foreign Relations Committee Hearings. Brown stated that the US Administration had "high confidence" in its ability to monitor the number of fixed ICBM launchers, SLBM launchers and heavy bombers. It is unclear whether this applied also to Soviet short-range nuclear missiles. Confidence would also be high for monitoring Soviet delivery vehicle testing, but, because of the difficulties associated with monitoring a freeze on production, confidence in that area would not be very high.

Provisions for national technical means of verification with associated cooperative measures could probably be negotiated without much difficulty. On-site inspection, however, would pose a significant obstacle to negotiations. Problems would be exacerbated if the freeze allowed production and deployment to replace systems and maintain forces at current levels. On the whole, an "adequately verifiable" freeze would create enough benefits to outweigh the margin of probability that militarily significant violations would go undetected.

Proposal Abstract J132(A84)

1. **Arms Control Problem:**
   Nuclear weapons - research and development
   - ballistic missiles
   - cruise missiles
   - proliferation
   - comprehensive test ban
   - fissionable material "cutoff"
   - nuclear freeze

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   - challenge
   - IAEA safeguards
   (c) International exchange of information - declarations
   (d) Seismic sensors - intra-border stations

3. **Source:**
   Scoville, Herbert. "First Steps Toward a Freeze". In The Nuclear Weapons Freeze and Arms Control, pp. 75-80. Edited by Steven E. Miller. Cambridge, Mass.: Ballinger, 1984.

4. **Summary:**

Scoville suggests that American intelligence capabilities and cooperative measures could provide "quite acceptable verification that the Soviets were not violating a freeze ... to the extent that our security would be significantly affected" (p.77). A freeze on selected programs should include the testing, production and deployment of the systems, although all these phases may not be equally important or verifiable.

The first priority in a freeze should be given to destabilizing strategic weapons systems which have a first strike potential against the other country's deterrent force or its political and military command and control structure. These systems include: Soviet SS-18s and SS-19s (which could be modernized), SS-20s and the recently reported new Soviet ICBMs (SS-Xs); and the American Minuteman IIIs (which could be modernized) and MX program (which should be halted). The SALT II agreement already provides for verification of the testing and deployment phases of these programs and "this should be even easier for a freeze where the programs would be totally halted" (p.76). Monitoring the modernization of SS-18s and SS-19s and Minuteman III could pose a problem since testing of improved guidance systems has almost been completed, but Scoville notes that "the administration has been reporting regularly on the status of such modernization programs so that any significant change of the status of these programs if the testing, production and deployment were all halted completely should be verifiable with an acceptable risk to our security" (p.76-77).

Verification of a production halt by national technical means could be enhanced by each side's declaring the locations where the major components of each frozen weapons system are produced. The continued operation of a declared plant or the conversion of a new plant to produce banned systems would pose a high risk of detection.

The deployment of the mobile SS-20 missile can be monitored satisfactorily and the testing of new types of missiles in this category would be easily detected.

A freeze on cruise missiles should also receive priority. Since they have not yet been deployed, a freeze on cruise missile testing and deployment would be easy to verify. This will not be the case once they are deployed in significant numbers.

A Comprehensive Test Ban Treaty (CTBT) should be agreed upon to help halt nuclear proliferation. In previous negotiations, the United States, United Kingdom and Soviet Union agreed to verification provisions for a CTBT, including challenge inspections and unmanned seismic stations in the Soviet Union. Scoville comments that these arrangements are "quite satisfactory for tests down to about a kiloton or even less" (p.78).

Verification of a fissionable materials 'cutoff' would be "comparatively easy" (p.79). A plant large enough to produce significant quantities of plutonium and uranium 235 would not escape detection by American national intelligence. The continued operation of existing weapons production plants in the Soviet Union would also be detected. IAEA safeguards could detect the diversion of significant quantities of plutonium produced in nuclear power plants. If the Soviet Union accepted such safeguards on its peaceful nuclear program, this would create an important precedent in the campaign to halt nuclear proliferation. The Soviets have indicated some willingness to move in this direction.

J133(A80)

Proposal Abstract J133(A80)

1. **Arms Control Problem:**
   Chemical weapons - destruction of facilities

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective

3. **Source:**
   Mikulak, R. "Destruction of US chemical weapons production and filling facilities". In Stockholm International Peace Research Institute, Chemical Weapons: Destruction and Conversion, pp. 57-66. London: Taylor and Francis, 1980.

4. **Summary:**

   After facilities have been declared as CW production plants, the first step is to verify that this is true. The simplest and most reliable way to do this is through on-site inspection by technical experts.

   In the initial phases of actual destruction of the plant the following might be observed:
   (1) delivery and storage of large quantities of decontaminant chemicals,
   (2) disposal in open ponds of liquid wastes,
   (3) installation and operation of equipment for spray-drying of liquid wastes.
   (4) installation and operation of a metal parts furnace, and
   (5) accumulation of piles of scrap metal.

   If much of the process equipment were located in the open, destruction could be observed directly. However, for facilities where equipment is housed indoors most of the destruction could only be monitored indirectly. If scrap piles were observed remotely, they could be compared with the equipment noted on previous on-site visits. But even for indoor equipment, some dismantling might be observable directly such as removal of external storage tanks. Demolition of buildings could be easily monitored from a distance and would provide the simplest and most conclusive evidence that the facility had been destroyed. Remote monitoring might be facilitated by prior agreement on the procedures to be employed in destruction and dismantling.

Proposal Abstract J134(G84)

1. **Arms Control Problem:**
   Chemical weapons - destruction of stocks
   - destruction of facilities

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - general
   - challenge
   (c) International control organization

3. **Source:**
   Australia. CD/PV.271, 10 July 1984.

4. **Summary:**

Australia proposes that the process of destruction of chemical weapons stocks and production facilities should be controlled by a centralized computer facility. An executive subgroup of the Consultative Committee could store data concerning the destruction process and communicate with on-site computers as necessary. All stages of destruction would be monitored and information would be updated by remote sensing techniques verified by inspection teams. The use of modern equipment can reduce the manpower required for on-site inspections and reduce the number of challenge inspections, but the continuous presence of inspectors would still be necessary to ensure effective verification.

Proposal Abstract J135(A77)

1. **Arms Control Problem:**
   Chemical weapons - production
   - stockpiling
   - destruction of stocks

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
   (c) International exchange of information

3. **Source:**
   Mikulak, Robert. "Preventing Chemical Warfare". In Chemical Weapons and Chemical Arms Control, pp. 65-80. Papers from a conference at the American Academy of Arts and Sciences, Boston from 21-22 January 1977. New York: Carnegie Endowment for International Peace, 1978.

4. **Summary:**

The author considers the effectiveness of chemical weapons and the defenses against them. He looks at possible methods for preventing chemical attack and concludes that maintaining a marginal offensive chemical warfare capability as a deterrent and producing incapacitants as a deterrent or retaliatory measure have little value. The best solution is to improve defenses against chemical attack and combine that with arms control.

Verification of an arms control agreement which prohibits the development, production, stockpiling or transfer of chemical weapons and requires the destruction of existing stocks would be difficult. Remote sensing is not useful because there are no observable features of chemical weapons agent production and storage. On-site inspection would not necessarily provide a high level of assurance of compliance, but could be effective in the particular task of verifying the destruction of declared stocks. A verification regime could utilize the following techniques: (1) exchange of data on chemical production, existing stockpiles and facilities; (2) on-site inspection of destruction of stocks and shut-down facilities; (3) inspection of facilities where prohibited activities are suspected; and (4) national technical means of verification.

In order to overcome the problem of verifying complete destruction of stocks, it would be possible to use a phased approach in which the prohibition might apply to all chemical weapons-related activities, but only for specified agents.

 J136(G72)

Proposal Abstract J136(G72)

1. **Arms Control Problem:**
   Chemical weapons - research and development

2. **Verification Type:**
   Remote sensors - satellite

4. **Source:**
   United Kingdom. "Working paper on remote detection of chemical weapons field tests". CCD/371, 27 June 1972.

4. **Summary:**
It is assumed in this paper that field testing would be an essential part of any development of a CW. However, this applies only with respect to new weapons. Consequently, the verification technique proposed here will not be useful for detecting CWs already in existing stocks. The paper describes the sensitivity and performance requirements of satellite sensors and gives probability estimates for detection a CW field test.

The paper comes to the conclusion that limited detection by satellite sensors of chemical field tests of known agents is technically possible. The most promising system is an infra-red sensor (photoconductive detector) mounted on a geostationary satellite. The incidence of cloud cover, however, is the major and a serious limiting factor.

Proposal Abstract J137(G76)

1. **Arms Control Problem:**
   Chemical weapons - research and development

2. **Verification Type:**
   Remote sensors - sampling

3. **Source:**
   United Kingdom. "Working paper on the feasibility of extraterritorial surveillance of chemical weapon tests by air monitoring at the border". CCD/502/Corr. 1, 2 July 1976.

4. **Summary:**

Two possible methods of remote verification of CW field tests involve the use of:

(1) satellites (discussed in CCD/371*), and

(2) ground stations situated outside national boundaries and equipped to detect CW agents in air masses which passed over areas where the weapons were thought to be tested.

Once a reliable indication of a violation had been obtained by the above techniques, on-site inspection would be called for. This paper assesses the second method's feasibility.

A number of analytical methods of monitoring air are presented (Appendix A of the working paper). It is concluded that the most sensitive method of instantaneous monitoring with a capability for identification is the Fourier infra-red technique similar to that which might be used on a satellite. The most sensitive system for sample accumulation with subsequent analysis would combine a highly efficient sampler with gas chromatographic analysis using a specific phosphorus detector.

An assessment of these techniques' chances of success if made using calculations based on general meteorological knowledge and conditions around three sites in particular. It is concluded that:

(1) Detection of a field test by instantaneous monitoring of air at a national boundary is not feasible at a distance of 10,000 km from the source and could probably not be achieved beyond a distance of 500 km.

(2) A sample accumulation system might theoretically detect an organophosphorous compound in a puff released 10,000 km upwind. But this conclusion still requires further study.

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* See abstract J136(G72)

(3) Identification of organophosphorous agents by the system described is not possible and in view of the risk of false alarm resulting from the detection of commercial compound, this system is not worthy of further consideration until the identification threshold is improved.

Proposal Abstract J138(G77)

1. **Arms Control Problem:**
   Chemical weapons - research and development
   - production
   - stockpiling
   - destruction of stocks

2. **Verification Type:**
   (a) Remote sensors - satellite
   (b) Records monitoring - economic
   (c) Literature survey

3. **Source:**
   Union of Soviet Socialist Republics. "Some methods of monitoring compliance with an agreement on the prohibition of chemical weapons". CCD/538, 3 August 1977.

4. **Summary:**

The working paper states that there are two methods of verifying a CW ban: intraterritorial and extraterritorial monitoring. Intraterritorial monitoring can be further subdivided into international and national monitoring. All technical means of verification including laboratory, remote, indirect (i.e. analysis of statistics), and conservative methods (i.e. sealing installations, telemetric and radiometric surveillance) are fully applicable to intraterritorial national monitoring. However, the use of these means in international monitoring is "inevitably associated with the disclosure of military, industrial and commercial secrets and consequently cannot be justified from the the standpoint of assuring the security and economic interests of the States parties to a future agreement. The present paper therefore takes as its starting point the need to assess the applicability of the above methods to extraterritorial monitoring."

Development (including testing) of CWs:

Indirect extraterritorial monitoring in this regard might involve searching for the presence of:

(1) research centres,
(2) testing centres in active operation, and
(3) specific systems of scientific and technical planning and financing.

Additionally, monitoring published patents and scientific publications which indirectly reflect the interests of specialized chemists, could be useful. Undeclared tests might also be detected using remote instrumentation techniques.

Production of CWs:

This could be monitored by recording and analysing the various emissions from chemical plants into the air and water using remote techniques. Indirect methods, particularly statistical analysis based on estimates of consumption of initial and intermediate substances used in the production of CWs, is an especially promising approach.

Stockpiling of agents and munitions:

This is virtually impossible to detect directly by extraterritorial means. Detection by remote methods of transport operations, however, is possible. Indirect methods especially statistical analysis of inter-state monetary and financial transactions (i.e. to detect transfer of CWs between states) may be of some importance.

Destruction of Stocks:

This can be monitored by a remote method - recording with sensitive instruments of specific gaseous substances which may be discharged into the atmosphere as a result of the destruction process. Indirect monitoring is feasible only where destruction entails making material preparations. Also destruction may entail substantial expenditure and may thus be reflected in the budgets.

The above analysis leads to the following conclusions:

(1) The most effective monitoring system involves the use of "national means ... for the purpose of intraterritorial national and extraterritorial monitoring".

(2) "laboratory, remote, indirect and conservative methods can be used in intraterritorial national monitoring in all cases".

(3) "extraterritorial monitoring can be performed chiefly by remote and indirect methods".

Remote methods:

The working paper continues with a more detailed examination of remote monitoring. This method, the paper claims, can be employed in two situations:

(1) Where a sample for monitoring is delivered naturally in a current of air or water and samples are taken for laboratory analysis. This method depends to a great degree on natural conditions and phenomena.

(2) "Where analysis is based on remote appraisal of some optical (spectral) characteristics of the monitored sample" through the use of artificial satellites. This method, the paper claims, is the more reliable.

A previous UK working paper on satellite detection of CW field tests* is mentioned. The Soviets suggest that a better instrument than that suggested in the UK paper would be "a monolithic detector based on impure crystals at ultra low temperatures (a condition easily attainable in outer space)". Other ways to achieve high detection sensitivity include the use of "the induced and resonance combination scattering (Shorygin) effect" employing modulated lasers.

The paper continues with its technical discussion of detection devices. It suggests that the best employment of detectors would involve "the use of a combined system in which one satellite is positioned in geostationary orbit while others revolve in low circular orbits at an altitude of about 250km."

The working paper claims that through improved instrumentation it will be possible "to record with a high degree of reliability the presence in the atmosphere of very low concentrations of chemical agents and consequently to detect the production of chemical weapons and field tests of such weapons".

Indirect methods:

These are effective for extraterritorial monitoring when based on analytical processing of a wide range of information accessible to the general public concerning the development, production and stockpiling of chemical agents. "In addition use may be made of the national information centres already in existence which analyse for commercial purposes the activities of various foreign research centres, factories, firms ..." and individual scientists. Since such national systems for selecting and evaluating information in all fields of science and technology exist in the majority of developed states, it is almost impossible that any of these states could outstrip the others for a long period and on a large scale, in any branch of fundamental military technology including chemical weapons without being detected. The paper concludes:

> Thus the sum total of remote and indirect methods of monitoring afford adequate scope for extraterritorial monitoring by national means. By combining those methods with the specific methods of intraterritorial national monitoring ... a comprehensive and effective solution can be found for the entire problem of monitoring compliance with an agreement on the prohibition of chemical weapons.

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* CCD/371, abstract J136(G72)

Proposal Abstract J139(A74)

1. **Arms Control Problem:**
   (a) Conventional weapons - ground forces
   (b) Regional arms control - Europe

2. **Verification Type:**
   (a) Remote sensors - aerial
   - satellites
   (b) On-site inspection - control posts
   (c) International exchange of information

3. **Source:**
   Coffey, J.I. New Approaches to Arms Reduction in Europe, Adelphi Papers #105. London: International Institute of Strategic Studies, 1974.

4. **Summary:**

Three alternative proposals are actually contained in this paper to verify either the existence of forces, their reduction or their withdrawal.

First, if country X questions whether country Y has really withdrawn all its tanks, from a prescribed border zone for example, Y could send X aerial photos of the zone, the validity and timing of which could be easily verified by national means. If the photos showed no tanks, X would know there had been no tanks there at all or that the tanks had been removed before the photos were taken.

Second, Y could announce the location of the units suspected of being in the zone, inviting observation by X (or Z) to verify that the units were in fact elsewhere. This would avoid extensive extra-national inspection systems. Supplementary to these two proposals, the author suggests that an agreement could be reached not to interfere with aircraft equipped with side-looking radar flying along but not across national boundaries.

Third, parties to an agreement could permit overflights of given areas (such as border zones) or a small number of "on call" flights through these zones, along main lines of communication or over prescribed areas which might serve as jump-off points for attacks, or sites for the build-up of supplies and equipment.

These measures would complement other national means of verification such as observation posts and satellites. Together they could provide a maximum of reassurance against gross violations of restrictions on deployment, without involving the acquisition of the sort of detailed information about systems and military installations which might derive from general on-site inspection.

Proposal Abstract J140(A74)

1. **Arms Control Problem:**
Conventional weapons - ground forces

2. **Verification Type:**
Remote sensors - satellite

3. **Source:**
Scoville, H. "A Leap Forward in Verification". In <u>SALT: The Moscow Agreements and Beyond</u>, pp. 160-182. Edited by M. Willrich and J.B. Rhinelander. New York: The Free Press, 1974.

4. **Summary:**
This proposal suggests that significant troop movements can be monitored, at least in daylight, by visible light photography by satellites. Military equipment could also be monitored by satellite sensors, even if camouflaged. The author proposes that any agreement seeking to restrict troop deployments (in Europe for instance) should include a clause similar to Article XII of the ABM Treaty making it a violation to deliberately conceal redeployments of troops and military vehicles. If it were further stipulated that troops and military vehicles could only cross borders at specific points, and only during the daytime, the work of verification would be greatly simplified. Such provisions would also assist in the task of differentiating between normal resupply operations and the reintroduction or redeployment of forbidden forces.

J140.1(G86)

Proposal Abstract J140.1(G86)

1. **Arms Control Problem:**
   Conventional weapons - ground forces

2. **Verification Type:**
   (a) Remote sensors
   (b) On-site inspection - selective
       - control posts
   (c) International exchange of information
   (d) Complaints procedure - consultative commission

3. **Source:**
   Hungary. "Letter dated 12 June 1986 Addressed to the President of the Conference on Disarmament by the Permanent Representative of the Hungarian People's Republic transmitting the text of the communique issued on the meeting of the Political Consultative Committee of the Warsaw Treaty Member States, held in Budapest on 10-11 June 1986 and the appeal by the same states to the member states of NATO and to all European countries". CD/700, 16 June 1986.

4. **Summary:**

The appeal contains a number of specific proposals on the reduction of armed forces and conventional armaments in Europe and also contains specific proposals for verification of such an agreement. Verification would be carried out through national technical means and international procedures including on-site inspection. Observation of the military activities of troops remaining after reduction was proposed. Also for purposes of verification the parties would exchange data on the total troop strength of their land forces and tactical strike air forces stationed in the zone of reduction and separately on their components to be reduced and on those not affected by the reduction. They would exchange information concerning the designations of the formations to be dismantled, their troop strength, location and the quantity of their main types of weapons agreed upon. The parties would notify each other of the beginning and completion of the reduction.

An international consultative committee would be formed with the participation of representatives of NATO and the Warsaw Treaty as well as of interested neutral and nonaligned and other countries of Europe. On-site inspection of the reduction of armed forces and the destruction or stockpiling of armaments could be carried out, if necessary, with the involvement of representatives of the international consultative committee. International control posts would be established at major railway centres, airports and harbours.

Proposal Abstract J141(I85)

1. **Arms Control Problem:**
   Conventional weapons - ships

2. **Verification Type:**
   (a) Remote sensors - satellite
   - aerial
   - shipboard

   (b) On-site inspection - selective

3. **Source:**
   United Nations. "Study on the Naval Arms Race: Report of the Secretary-General". A/40/535, 17 September 1985.

4. **Summary:**

This study examines the naval arms race in order to analyse its implications for international security, the freedom of the high seas, international shipping routes and the exploitation of marine resources. The fact that "a significant portion of the world's strategic nuclear capability is at sea" (p.88) places urgency on the need for negotiations leading to nuclear disarmament. The study lists possible measures for both quantitative and qualitative restraints and explores possible methods of verification and confidence-building measures.

The study notes that verification of naval disarmament has a number of features which distinguish it from verification of disarmament measures on land. First, verification at sea does not involve intrusion into or violation of land territory or territorial airspace if it is performed on the high seas and does not involve on-site inspection. Second, the specific physical limitations of naval vessels and naval aircraft permit the monitoring and identification of their presence and movements under certain circumstances. Third, verification is facilitated by the international nature and freedom of the high seas as long as the necessary physical and technical means are available. However, problems for verification are posed by submarines and the identification of which ships are, or may be, carrying nuclear weapons. Furthermore, the study notes that "measures to restrain technological improvements are generally very difficult to verify unless a particular technological element is altogether banned" (p.80).

Possible verification measures for naval disarmament include detection devices on satellites, aircraft or other vessels as well as devices could be deployed underwater. "Verification teams" could consist of representatives of (a) states participating in the measures, (b) international or regional organizations, or (c) neutral or other states from within, or outside, the area concerned. Confidence-building measures providing for openness and the transfer of information could enhance verification procedures.